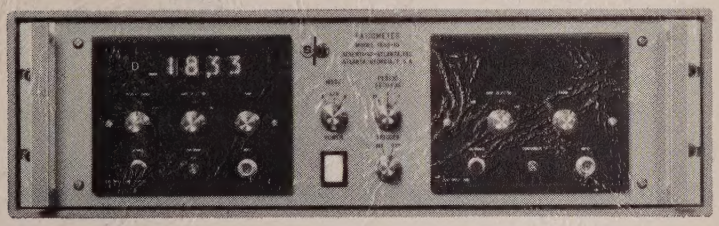
Instruction Manual

SERIES 1833A LOGARITHMIC RATIOMETER

Logarithmic Ratiometer
Series 1833A



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SERIES 1833A
LOGARITHMIC RATIOMETER

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SCIENTIFIC-ATLANTA, INC.
P. O. Box 13654, Atlanta, Ga. 30324

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TABLE OF CONTENTS

Paragraph		Page
	CHAPTER 1 GENERAL INFORMATION	
1.1	General	1-1
1.2	Purpose of Equipment	1-1
1.3	General Description	1-1
1.4	Technical Characteristics	1-2
	CHAPTER 2 INSTALLATION	
2.1	General	2-1
2.2	Unpacking and Inspection	2-1
2.3	Installation	2-1
2.3.1	Instrument Location	2-1
2.3.2	Elimination of 60-Hz Pickup (HUM)	2-2
2.3.3	Installation Procedure	2-2
	CHAPTER 3 OPERATION	
3.1	General	3-1
3.2	Controls and Indicators	3-1
3.3	Operation	3-5
3.3.1	Initial Operation	3-5

TABLE OF CONTENTS - continued

Paragraph		Page
3.3.2	Operating Procedures	3-6

CHAPTER 4
THEORY OF OPERATION

4.1	General	4-1
4.2	Block Diagram Discussion	4-2
4.2.1	Analog Subsystem Description	4-2
4.2.2	Digital Subsystem Description	4-6
4.3	Detailed Discussion	4-8
4.3.1	Analog Subsystem Discussion	4-8
4.3.2	Digital Subsystem	4-15
4.3.3	Power Supply Circuits (A10)	4-33

CHAPTER 5
MAINTENANCE

5.1	General	5-1
5.2	Visual Inspection	5-1
5.3	Cleaning	5-1
5.4	Semiconductor Maintenance	5-2
5.5	Maintenance Equipment	5-3
5.6	General Troubleshooting	5-4
5.7	Logic Troubleshooting	5-5
5.7.1	TTL Troubleshooting	5-5
5.7.2	DTL Troubleshooting	5-6
5.7.3	DTL Troubleshooting Hints	5-9

TABLE OF CONTENTS - continued

Paragraph		Page
5.8	Adjustments	5-9
5.8.1	Power Supply Adjustments	5-11
5.8.2	Analog Subsystem Alignment Procedure	5-11
5.8.3	Digital Subsystem Alignment Procedure	5-23

CHAPTER 6
PARTS LISTS

6.1	General	6-1
6.2	Explanation of Column Headings	6-1
6.3	Ordering Parts	6-2
6.4	Optional Module Reference Designation Chart	6-2

CHAPTER 7
DIAGRAMS

LIST OF ILLUSTRATIONS

Figure		Page
1-1	Model 1833A-10 Logarithmic Ratiometer In Optima E5 Case	1-0
3-1	Ratiometer Front Panel Controls	3-3
4-1	Ratiometer Simplified Block Diagram	4-3
4-2	Analog Subsystem Block Diagram	4-5
4-3	Digital Subsystem Block Diagram	4-7
4-4	Simplified Logic Level Diagram	4-21
4-5	Simplified Logic Level Diagram	4-24
4-6	Simplified Logic Level Diagram	4-26
4-7	Simplified Logic Level Diagram	4-30
5-1	Test Equipment Set-Up	5-13
5-2	Idealized Adjustment Waveforms	5-15
5-3	Test Equipment Set-Up	5-20

FIGURE NO.	TITLE	PAGE NO.
7-1	Model 1833A Ratiometer	7-1
7-2	Mother Board Assembly (A1)	7-2
7-3	Model 1833A Ratiometer	7-3
7-4	Bolometer Current Assembly (A1A1)	7-4
7-5	Filter/Bolometer Current (A1A1)	7-5
7-6	Synchronous Demodulator Assembly (A1A2)	7-6
7-7	Synchronous Demodulator (A1A2)	7-7
7-8	Reference Limiter Assembly (A1A3)	7-8
7-9	Reference Limiter (A1A3)	7-9
7-10	Lin/Log Amplifier Assembly (A1A4)	7-10
7-11	Lin/Log Amplifier (A1A4)	7-11
7-12	Interconnect & 6.4 MHz Oscillator Assembly (A1A5)	7-12
7-13	Interconnect & 6.4 MHz Oscillator (A1A5)	7-13
7-14	Control Logic Assembly (A1A5A1)	7-14
7-15	Control Logic (A1A5A1)	7-15
7-16	Dual Slope Integrator Assembly (A1A5A2)	7-16
7-17	Dual Slope Integrator (A1A5A2)	7-17
7-18	Display Module Assembly (A2)	7-18
7-19	Display Module (A2)	7-19
7-20	BCD Byte Output Assembly (A3*)	7-20
7-21	BCD Byte Output (A3*)	7-21
7-22	BCD Output Assembly (A3*)	7-22
7-23	BCD Output (A3*)	7-23
7-24	Input Amplifier/Display Assembly (A4)	7-24
7-25	Input Amplifier/Display (A4)	7-25
7-26	Preamplifier/Display Assembly (A4*)	7-26
7-27	Preamplifier and Control Unit (A4*)	7-27
7-28	CBA Preamplifier Assembly	7-28
7-29	CBA Preamplifier	7-29
7-30	Signal Input Assembly (A4*A1)	7-30

FIGURE NO.	TITLE	PAGE NO.
7-31	Preamplifier and Control Unit (A4*A1)	7-31
7-32	Difference Module Assembly (A9)	7-32
7-33	Difference Module (A9)	7-33
7-34	Overall Power Supply (A10)	7-35
7-35	±15 Volt Power Supply Assembly (A10A1)	7-36
7-36	±15 Volt Power Supply (A10A1)	7-37
7-37	5 Volt & 250 Volt Power Supply Assembly (A10A2)	7-38
7-38	5 Volt & 250 Volt Power Supply (A10A2)	7-39

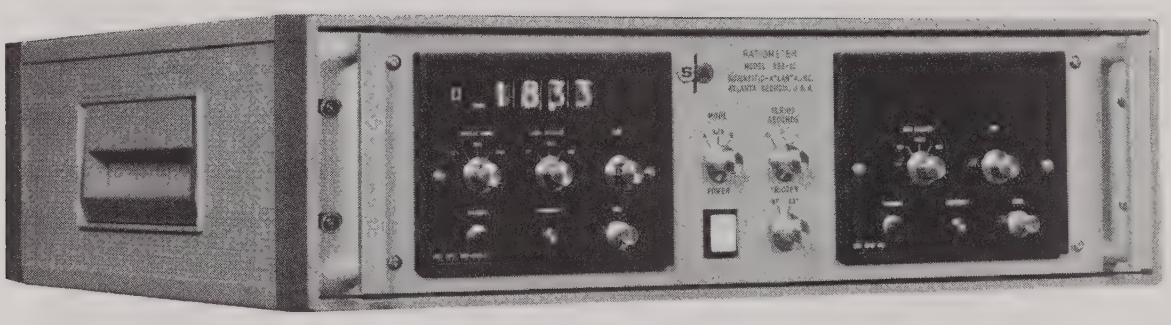


Figure 1-1. Model 1833A-10 Logarithmic Ratiometer In Optima E5 Case

CHAPTER 1
GENERAL INFORMATION

1.1 GENERAL

This instruction manual contains information necessary to install, operate, and maintain Scientific-Atlanta Series 1833A Logarithmic Ratiometer units. Schematic diagrams and parts lists are also included. Changes, if any, are described in the notice following the title page. Standard options are described in this manual.

1.2 PURPOSE OF EQUIPMENT

The Scientific-Atlanta 1833A Ratiometer units are designed to permit rapid and accurate conversion of ac signal levels (or the ratio or product of two input signals) to a logarithmic binary-coded-decimal (BCD) digital output and a decimal display. A dc analog output is provided. The instrument presents both BCD (optional) and dc outputs as linear or logarithmic functions of the ac input signal. A linear ac output is also provided.

The ratiometer may be equipped with a crystal/bolometer preamplifier (optional) to allow measurement of low-level inputs from a crystal detector or from the bolometer output of a microwave receiver.

1.3 GENERAL DESCRIPTION

The Ratiometer consists of (optional) preamplifier, analog, difference, and digital sections. The preamplifier section contains a high-gain, low-noise, narrow-bandwidth crystal-bolometer amplifier. The analog section contains an ac-to-dc converter, and a linear/logarithmic amplifier. The difference section contains a difference amplifier, a sum amplifier, polarity sensing and switching circuitry, and out-of-range circuitry.

The digital section contains a dual-slope integrator, logic and counting circuitry, a digital display, and input/output buffer amplifiers for binary-coded-decimal (BCD) control, and timing signals.

Three display ranges are available, permitting the input to be read in percent of full-scale, or in dB referred to either a square-law detector, (with optional preamplifier) or a linear detector. The resolution is ±0.1 or ±0.01 dB, depending on the selected scale range. The BCD output is capable of interfacing with many computers and/or a magnetic tape recorder for making permanent, easily retrieved records.

The instrument is completely solid-state (except for display tubes) and utilizes integrated circuits to great advantage. The small size and low weight of the unit make it quite portable and ideally suited for both laboratory and antenna measurements.

1.4 TECHNICAL CHARACTERISTICS

Prior to operating the Ratiometer, the technical characteristics listed in Table 1-1 should be reviewed to ensure an understanding of the limits of its operation, and the operation characteristics that may be expected.

TABLE 1-1. TECHNICAL CHARACTERISTICS

Characteristic	Specification
General	
Voltage	115/230V ac (switch selectable)
Frequency	50/60 Hz
Power	50 watts
Weight	25 lb

TABLE 1-1. TECHNICAL CHARACTERISTICS - continued

Characteristic	Specification	
Size	Portable	Rack Mount
Height	5-1/4 in	5-1/4 in
Width	17 in	19 in (std EIA Panel)
Depth	17-1/2 in	17-1/2 in
Input Signal		
Level (Full Scale)	1V (rms), fixed gain	
Frequency	1000 Hz (nominal) (1025 for 50 Hz operation, 500 to 2500 Hz available on special order)	
Input Signal with Preamplifier	(optional)	
Input Sensitivity (Full Scale)		
Bolometer	100 µV	
Crystal	200 µV	
Input Frequency		
Standard	1000 Hz, nominal	
Optional	500 to 2500 Hz available on special order	
Bandwidth*	30 Hz (3-dB points), 1000 Hz center frequency (1025 for 50 Hz operation)	
Noise (200-ohm source resistance)	0.015 µV typical, 0.02µV maximum	
Attenuator Range		
Fixed	60dB, 20-dB steps	
Variable	0 to 20 dB, minimum	
Accuracy	±0.2-dB per 20-dB step	

*Analog outputs, BCD output bandwidth is a function of the PERIOD control settings.

TABLE 1-1. TECHNICAL CHARACTERISTICS - continued

Characteristic	Specification
Input Impedance	
Standard	10K ohm nominal
Bolometer (option - 2)	300 ohms nominal
Crystal (option - 2)	1200 ohms nominal
Bolometer Bias (option - 2)	9 mA min (adjustable)
Visual Display	Three decade + 1 digit digital neon readout tubes
Readout Range	
Ch "A" or Ch "B"	
Expanded dB Range (0.01-dB resolution	+2 to -19.99 (linear detector),
	+1 to -10 (square-law detector)
Normal dB Range (0.1-dB resolution)	+5 to -80.0 (linear detector),
	+2 to -40.0 (square-law detector)
Linear Range (0.1% resolution)	0 to 110% full scale
Ratio "A/B"	
Expanded dB Range (0.01-dB resolution)	±19.99 (linear detector)
	±10 (square-law detector)
Normal dB Range (0.1-dB resolution)	±70 (linear detector)
	±35 (square-law detector)
Readout Accuracy	
Channel "A" or "B"	Log-0.1 dB ±1 least significant digit over 60- dB range
Ratio A/B and A·B	Linear-0.5% of full scale 0.03 dB per 10-dB signal change ± least significant digit over 60-dB range

TABLE 1-1. TECHNICAL CHARACTERISTICS - continued

Characteristic	Specification
Out-of-Range Indication	Visual indication (flashing decimals) if the input is above or below the readout range limits.
External Trigger	With the front-panel TRIGGER SELECTOR switch in the EXTERNAL position, the measurement is inititated when the external trigger line changes from a positive level to ground.
Conversion Time (Period)	Selectable; 0.01, 0.1, or 1.0 second (nominal)
Analog Outputs	
AC	Amplified 1000-Hz input signal 0.2V (rms) nominal for full scale (0 dB
DC (Channel A or B)	1000-ohm source with the scale factors shown below: 110% +10%/V 10 dB -1 dB/V 20 dB -2 dB/V 40 dB -5 dB/V 80 dB -10 dB/V
DC Log (PFA Output)	0.5V/10dB
Lin (PFA Output)	100 mV/10%
Digital Inputs	

NOTE

All digital input and output signals are diode-transistor logic (DTL) and transistor-transistor logic (TTL) compatible. A DTL low is defined as a level from 0 to +0.5V capable of drawing at least 12 mA. A DTL high is a level from +2.5V to +5V furnished by a 6000-ohm resistor to +5V.

TABLE 1-1. TECHNICAL CHARACTERISTICS - continued

Characteristics	Specification
UPDATE INHIBIT	A DTL low present on this line prevents the display and BCD outputs from updating.
Maximum Measurement in Progress Enable (MMIP ENABLE)	A DTL low present on this line causes the measurement in progress pulse to assume a length determined by the PERIOD switch and independent of input signal level.
External Trigger (EXT TRIG)	A DTL high-to-low transition initiates a measurement if the front panel TRIGGER switch is in the EXT position.
Measurement in Progress (MIP)	A DTL low is present on this line while the system is converting and updating. The system cannot be triggered or updated while this line is low. The duration of this condition is normally a function of the front panel PERIOD switch position and input signal level (see MMIP ENABLE).
INT TRIG	A 300-ns DTL low pulse occurs on this line at the beginning of each measurement while the front panel TRIGGER switch is in the INT position. When the TRIGGER switch is placed in the EXT position, this line is a DTL high.
READ INHIBIT	This line remains at a DTL low as long as MIP or UPDATE INHIBIT is low.
DATA LAMP	This line goes to a DTL high when update occurs, and to a DTL low 1 to 100 ms after initiation of the next measurement, depending on the setting of the PERIOD switch.

TABLE 1-1. TECHNICAL CHARACTERISTICS - continued

Characteristic	Specification
BCD DATA (OPTION -1)	
NOTE All lines shown below are independently buffered, DTL positive-logic outputs. These outputs duplicate digital display signals.	
DATA	Thirteen lines of 8421 binary-coded decimal (BCD) data.
SIGN	+ Sign (DTL low for a minus sign)
10^{-1} DECIMAL POINT	DTL high when display resolution is 0.1.
10^{-2} DECIMAL POINT	DTL high when display resolution is 0.01.
OUT OF RANGE	DTL high for data either above or below the display range capability.
BYTE DATA (OPTION -4)	
DATA	8 lines of BYTE 1 and 2 8421 BCD Digital Data Information.
SIGN	+ Sign (DTL low for a plus sign)
10^{-1} DECIMAL POINT	DTL low when resolution is 0.1 (high when .01).
OUT OF RANGE	DTL low for data either above or below the range capability.

CHAPTER 2
INSTALLATION

2.1 GENERAL

This chapter contains general information necessary to install and initially operate Series 1833A Logarithmic Ratiometers.

2.2 UNPACKING AND INSPECTION

Carefully unpack the shipping carton, inspecting all items for shipping damage. If damage is evident, contact the carrier and the nearest Scientific-Atlanta sales representative immediately. Save the packing materials and shipping papers for inspection by the carrier's representative. Do not return the instrument without receiving specific return shipment instructions from the factory.

The shipping carton may be used for storage or further transport of the instrument, if desired.

Save all packing material until satisfactory operation of the instrument is obtained.

2.3 INSTALLATION

2.3.1 INSTRUMENT LOCATION

The instrument may be either bench or rack-mounted. To locate the instrument on a bench, place it in a convenient place and connect as directed in Paragraph 2.3.2. The unit may be supplied in a rack or console by the user. Scientific-Atlanta Optima* mounting panels and brackets are available for rack or console mounting.

*Registered Trade Mark

2.3.2 ELIMINATION OF 60-Hz PICKUP (HUM)

To obtain maximum sensitivity from the instrument input amplifier or optional preamplifier, exercise care to eliminate undesirable 60-Hz pickup (hum) in the input cable. The instrument's 60-dB rejection of 60 Hz eliminates most error possibility, but the instrument is extremely sensitive, and such undesirable pickup may be detectable with low-level signals. Hum at the amplifier input (exclusive of that associated with the received signal) occurs when 60-Hz currents are allowed to flow in the shield of the input cable, such as when the detector mount is not at ground potential with respect to the instrument ground. Hum may also be induced in the input cable if power cables are run beside it.

To reduce 60-Hz pickup, proper grounding or complete isolation of the detector mount is required. Adequate isolation of the input cable from undesirable electro-magnetic fields is desirable.

Hum may be minimized by use of a triaxial input cable. Triaxial cable equivalent to Amphenol Type 21-204 is recommended. Cable lengths of up to several thousand feet may be used without undesirable effects if the cable is properly grounded and isolated.

2.3.3 INSTALLATION PROCEDURE

Installation of the digital ratiometer unit consists largely of properly interconnecting the cables to the unit. A recommended installation procedure follows.

NOTE

Before supplying power to the instrument, refer to Paragraph 3.3.1 for initial operating instructions.

a. Place the rear panel Power switch to the desired operating voltage (115/230).
b. Connect all cables, for operations desired, according to Table 2-1.
c. Refer to Paragraph 3.3.1 for initial turn-on instructions.
d. Plug the three-prong power cord into a grounded, three-prong, 115-volt (230 optional) ±10%, 50- or 60-Hz ac, 50-watt power outlet.
e. Turn the instrument on (push the POWER switch in) and allow it to warm up.
f. Thoroughly test the instrument's operation. If defects are noted during initial installation after shipment from the factory, contact the nearest Scientific-Atlanta sales representative immediately.
g. If no defects are noted, installation of the ratiometer may be considered complete. Refer to Paragraph 3.3.2 for operating procedures.

TABLE 2-1. INPUT/OUTPUT CONNECTOR DETAILS

REF.	TITLE	TYPE	MATING CONNECTOR FSCM	MATING CONNECTOR PART NO.	LOCATION	DESCRIPTION
J1	Input	BNC	02660	UG-88/V	Front Panel	Channel "A" AC Signal Input (parallel with rear panel J2)
J2	Input	BNC	02660	UG-88/V	Rear Panel	Channel "A" AC Signal Input (parallel with front panel J1)
J3	AC Output	BNC	02660	UG-88/V	Rear Panel	Channel "A" AC Analog Output
J4	DC Output	BNC	02660	UG-88/V	Rear Panel	Channel "A" DC Analog Output
J5	Ext. Control	10 Cond	81312	M10PLSH19C	Rear Panel	Channel "A" External Control

PIN DETAIL

A	Ground
B	Not Used
C	Not Used
D	MMIP Enable (Input)
E	Internal Trigger (Output)
F	Update Inhibit (Input)
H	Read Inhibit (Output)
J	Not Used
K	External Trigger (In)
L	MIP (Output)

(Continued)

TABLE 2-1. INPUT/OUTPUT CONNECTOR DETAILS

REF.	TITLE	TYPE	MATING CONNECTOR FSCM	MATING CONNECTOR PART NO.	LOCATION	DESCRIPTION
J6	Digital Output	50 Cond	02660	57-30500	Rear Panel	BCD Digital Data Output Model 1833A-10; Ratio, Prod. or "A" or "B" Model 1833A-20; Channel "A" or Ratio or Prod.

PIN DETAIL; OPTION 1* (Parallel BCD Output)

1	1	26	4
2	2	27	8
3	10	28	40
4	20	29	80
5	100	30	400
6	200	31	800
7	1000	32-39	Logic 0 Not Rec. For Use ***
8-13	Logic 0, Not Rec. for use	40	Multiplier X 10^{-2}
14	Over Range; Logic 1 = Over Range, 0 = In Range	41	Logic 0 Not Rec. For Use ***
		42	Not Used
15	Sign; Logic 1 = Pos., Logic 0 = Neg.	43	Spare
		44	Not Used
16	Multiplier X 10^{-1}	45	Spare
17-22	Not Used	46	Not Used
23	Data Lamp Out	47	Update Inhibit Input
24	VCC1 Out 5V @ 50 ma, max.	48	Not Used
25	VCC2 Input**	49	Not Used
		50	Ground

* Option 1 (Parallel BCD Output) Positive Logic used
Logic 1 = True = 5 volts at output
Logic 0 = True = 0 volts at output
Outputs DTL/TTL compatible

** VCC2 input supplies power input to inverters 1C4, 5, and 6. Connect Pin 25 to Pin 24 if internal VCC1 is used.

*** Logic 0, not recommended for circuit ground

(Continued)

TABLE 2-1. INPUT/OUTPUT CONNECTOR DETAILS

REF.	TITLE	TYPE	MATING CONNECTOR FSCM	MATING CONNECTOR PART NO.	LOCATION	DESCRIPTION
J6	Digital Output	50 Cond	02660	57-30500	Rear Panel	BCD Digital Data Output Model 1833A-10; Ratio, Prod. or "A" or "B" Model 1833A-20; Channel "A" or Ratio or Prod.

PIN DETAIL; OPTION 4 (BCD BYTE OUTPUT)*

BIT	PIN NO.	BYTE 1	BYTE 2
1	1,2	1	100
2	3,4	2	200
3	5,6	4	400
4	7,8	8	800
5	9,10	10	1000
6	11,12	20	Sign; Logic 1 = Pos., Logic 0 = Neg.
7	13,14	40	Over Range; Logic 1 = Over Range, Logic 0 = In Range
8	15,16	80	Multiplier; Logic 1 X 10^{-1}, Logic 0 X 10^{-2}
	22	Select; Ground to Enable	
	23		Select; Ground to Enable

COMMON PINS

PIN NO.	
17	Data Lamp - Status of Front Panel Lamp
21	Update Inhibit - Logic 1 to Inhibit, Displayed Data Storage
19,20	Signal Ground

* Ground Logic used to allow wired "OR" function at BYTE Output
Logic 1 = True = 0 volts at output
Logic 0 = False = 5 volts at output
Outputs DTL/TTL compatible

(Continued)

TABLE 2-1. INPUT/OUTPUT CONNECTOR DETAILS

REF.	TITLE	TYPE	MATING CONNECTOR FSCM	MATING CONNECTOR PART NO.	LOCATION	DESCRIPTION
J7	Input	BNC	02660	UG-88/V	Front Panel	Channel "B" AC Signal input (parallel with rear panel J8)
J8	Input	BNC	02660	UG-88/V	Rear Panel	Channel "B" AC Signal input (parallel with front panel J7)
J9	AC Out	BNC	02660	UG-88/V	Rear Panel	Channel "B" AC Analog output
J10	DC Out	BNC	02660	UG-88/V	Rear Panel	Channel "B" DC Analog output
J11*	Ext. Control	10 Cond	81312	M10PLSH19C	Rear Panel	Channel "B" External Control
PINS	Same pin connections as J5. See J5 for details					
J12*	Digital Output	50 Cond	02660	57-30500	Rear Panel	Channel "B" BCD Digital Data Output
PINS	Same pin connections as J6. See J6 for details					

NOTE * Used only on Model 1833A-20

REF	TITLE	TYPE	MATING CONNECTOR		LOCATION	DESCRIPTION
			FSCM	PART NO.		
J13	PFA Output	14 Cond	02660	57-30140	Rear Panel	Output Voltages to PFA

PIN DETAIL

1	Ratio A/B Output 20 dB/Volt
2	Not Used
3	Chan A Log Output 20 dB/Volt
4	Chan A Lin Output 10%/100 mV
5	Chan B Log Output 20 dB/Volt
6	Chan B Lin Output 10%/100 mV
7	Chassis GRD
8	Product A-B Output 20 dB/Volt
9-13	Not Used
14	Chassis GRD

CHAPTER 3
OPERATION

3.1 GENERAL

This chapter contains information necessary to properly operate the Scientific-Atlanta Series 1833A Logarithmic Ratiometer units. Discussions of the front panel operating controls, indicators, and operating procedures are included.

Front panel controls, indicators, and adjustments are identified in UPPER-CASE letters. Rear panel controls and connectors are identified by Initial Upper Case letters.

3.2 CONTROLS AND INDICATORS

Table 3-1 lists the front panel controls, indicators, and adjustments (see also Figure 3-1). Their reference designations and brief descriptions of the controls, indicators, or adjustments are also listed.

TABLE 3-1. FRONT PANEL CONTROLS AND INDICATORS

Control	Description
AMPLITUDE Display	This display indicates the amplitude of the selected input signal. The readout will vary depending on the setting of the other front panel controls.
DISPLAY RANGE Control	A rotary switch which selects the range and resolution of the AMPLITUDE display, the ranges are as follows:

TABLE 3-1. FRONT PANEL CONTROLS AND INDICATORS

Control	Description
	(Referred to a linear detector) +2 to -19.99 dB +5 to -80 dB Ratio (A/B), Prod. (A·B) ±19.99 dB ±70 dB Referred to a square-law detector, on preamplifier option model only) +1 to -10 dB +2 to -40 dB Ratio (A/B), Prod. (A·B) ±10 dB ±35 dB
OUT OF RANGE Indicator	Out of range is indicated by the flashing of the right decimals on the display tubes when either the upper or lower limit of the selected range has been exceeded.
DATA Indicator	This lamp is illuminated each time the display is updated and is extinguished when the next measurement is begun.
TRIGGER INT/EXT Switch	This switch allows selection of the measurement trigger source
PERIOD SECONDS 0.01/0.1/1.0 Switch	This rotary switch selects the integration time and conversion time of the display.
BOLO/XTAL Switch (Preamplifier models Only)	A toggle switch which selects the proper input impedance match for either a crystal or bolometer input. In the BOLO position, a dc bolometer current is available.
CALIBRATE Switch	The CALIBRATE pushbutton switch gives a precise 10,000:1 attenuation when pressed.

TABLE 3-1. FRONT PANEL CONTROLS AND INDICATORS - continued

Control	Description
ATTENUATION,dB OFF/60/40/20/0 Switch (Preamplifier models only)	This rotary switch allows precise attenuation of the input signal. When the switch is in the OFF position, the input signal is prevented from reaching the input circuitry. This switch is calibrated in dB referred to a linear detector.
INPUT Connector	A BNC connector used to couple the input signal to the unit. The INPUT connector is in parallel on the rear.
GAIN SELECTOR (Models not equipped with Preamplifier)	When this switch is in the OFF position, the input signal is prevented from reaching the detector circuit. When in the FIXED position, the gain cannot be varied. When in the VAR position, the gain can be increased by approximately 10:1 (20dB) by the gain control knob. This rotary switch is used in place of the attenuator switch.
GAIN Control	The GAIN control allows a gain variation of 10:1 (minimum).
CALIBRATE Adjustment	This front panel screwdriver adjustment may be used to adjust the conformity of the logarithmic amplifier.
POWER Switch	This pushbutton switch is used to apply and remove power to the instrument.
MODE Switch	This switch selects the information to be displayed and converted to BCD output data in channel "A".

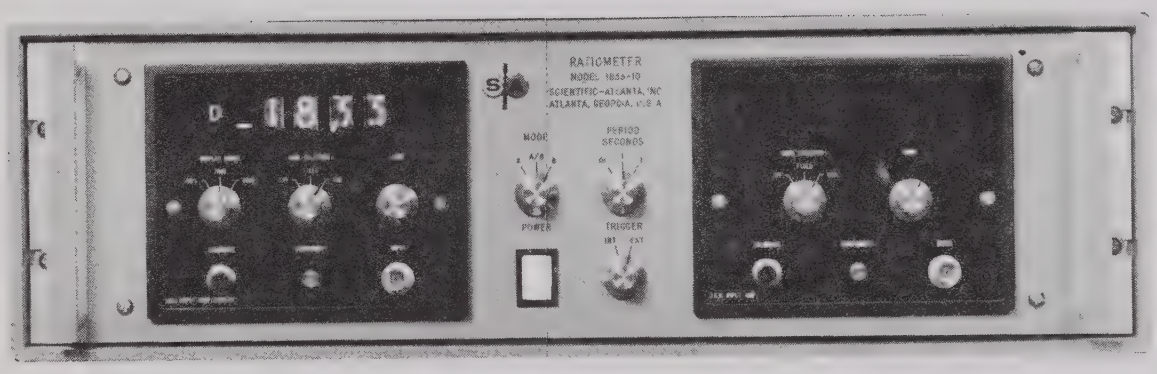


Figure 3-1. Ratiometer Front Panel Controls

3.3 OPERATION

3.3.1 INITIAL OPERATION

Before operating the instrument, check all cable connections for proper connection. After applying ac power, note signs of obvious damage or malfunction, such as unusual heating, fuse-blowing, etc. Before operating the instrument, note the considerations discussed below.

3.3.1.1 Amplifier Gain Adjustments. The amplifier will not saturate when the display is set within its limits. Use the ATTENUATION dB switch (preamplifier only) and/or GAIN control on the front panel to obtain the desired scale sensitivity. When using the unit without a preamplifier, adjust the signal source (receiver, etc.) gain to obtain the desired level.

3.3.1.2 Amplifier Bandwidth Considerations. The half-power bandwidth of the preamplifier is 30 Hz, and the rejection to 60 Hz is greater than 70 dB.

3.3.1.3 Crystal Detector (XTAL) Operating Setup. For operation of the instrument from the detected audio output of a crystal detector, connect the front panel INPUT connector (or rear panel Input connector) to the output of the crystal detector with a length of coaxial cable (see Paragraph 2.3.2). With an amplitude-modulated RF signal applied to the detector, adjust the modulation frequency to correspond with the center frequency of the crystal-bolometer amplifier in the instrument (1000 Hz standard, 500 Hz to 2500 Hz optional; see modification notice at the front of this manual if applicable). This will be indicated by a maximum reading on the display. The ATTENUATION, GAIN, and DISPLAY RANGE controls may be adjusted to obtain the desired display sensitivity.

3.3.1.4 Bolometer Detector (BOLO) Operating Setup. To operate the instrument from the detected audio output of a bolometer detector, place the BOLO/XTAL switch in the BOLO position.

NOTE

The bolometer current is adjustable to 4 mA unless otherwise requested.

Connect the output of the bolometer to either the front panel INPUT connector or the rear panel Input connector with an appropriate length of coaxial cable (see Paragraph 2.3.2). With an amplitude-modulated RF signal applied to the bolometer, adjust the modulation frequency to correspond to the center frequency of the crystal-bolometer amplifier. This will be indicated by maximum (more positive) indication on the display. The front panel GAIN (variable) and ATTENUATION dB controls may be adjusted to obtain the desired sensitivity (see Paragraph 4.3.1.4).

NOTE

A voltage-limiting circuit is included as part of the bolometer bias circuit to prevent bolometer burn-out if the bolometer is accidently disconnected and reconnected with bias applied.

3.3.2 OPERATING PROCEDURES

3.3.2.1 Standard Log Display Procedures. The basic operating procedures for an individual channel display follows:

a. Turn the instrument on by pushing the front panel POWER switch (switch becomes illuminated in the ON position), or apply system power if the instrument is used in a system.

b. Set the TRIGGER switch to INT (internal) unless external timing signals are used. If external timing signals are to be used, check to ensure that they are supplied to pin K of connectors J5 and J11 (J11 not used on -10 models).

c. Place the PERIOD switch to the desired period (0.01, 0.1, or 1 second). For setup purposes, the 0.1-second range is generally most useful (the 1-second position averages the signal over a longer period of time and produces a more accurate reading).

d. Place the MODE switch to the desired channel to be measured.

e. Set the DISPLAY RANGE switch for the desired full-scale range of the display.

f. Set the XTAL/BOLO switch (optional) to the desired position (see Paragraphs 3.3.1.3 and 3.3.1.4).

g. Adjust the input frequency for a maximum signal level. Adjust the ATTENUATION, dB switch and the GAIN control for a 0-dB (or 100% of full-scale) display indication if the input signal is fixed in amplitude and a preamplifier unit is used. If the unit is not equipped with a preamplifier switch the GAIN SELECTOR switch to FIXED and adjust the input signal by varying the gain of the receiver, etc.; for zero dB (or 100% of full-scale).

h. In the logarithmic modes, the conformity of the logarithmic amplifier should be checked prior to use to avoid errors. To check the logarithmic amplifier conformity, adjust the ATTENUATION and GAIN controls to obtain 0 dB for either the 40-dB or 80-dB range and press the CALIBRATE pushbutton located in the center of the front panel.

   The display should indicate -40 dB in the 40-dB (SQUARE LAW DET) DISPLAY RANGE, or -80 dB in the 80-dB (LIN DET) DISPLAY RANGE. The conformity may be corrected by holding in the CALIBRATE pushbutton and adjusting the front panel CALIBRATE screwdriver adjustment.

All preliminary operating procedures have now been completed. Further operation consists only of changing the front panel controls as required when a new display range or sensitivity is required. Switch settings may be changed as desired with the POWER switch ON.

When the MODE PERIOD switch or DISPLAY RANGE switch setting changes, the first and second readings following the setting change may be incorrect. The third and all subsequent readings will be correct.

3.3.2.2 Ratio Log Display Procedure. The basic operating procedure for measuring the ratio and product between two signals is similar to the individual channel display except both channels must be adjusted together.

The turn-on and switch selection is the same as outlined in the preceeding paragraph. The MODE selector switch is placed in the A/B position when ratio measurements are to be made. The DISPLAY RANGE switch is only operative on the dB scales when making ratio measurements.

Whereas the individual channels are usually adjusted at the maximum signal points, ratio adjustments may have to be made where one or both signals are at some other signal level.

Therefore, the operator must have a general knowledge of the signals to be measured and their approximate variation or he may check the signals as outlined in Paragraph 3.3.2.1. If the 20 dB DISPLAY RANGE is to be used for greater signal resolution, the signals in each channel must be within 20 dB of each other at all times during the measurement and within the individual channel measurement limits. If the 80-dB range is used, each channel must be within 70 dB of each other and within the individual channel measurement limits.

The most linear and accurate range in the RATIO mode is when the individual channels are between -5 and -60 dB. The instrument should be set to measure ratios when the individual channels are in this range, if possible.

The display indicates +dB when Channel "A" (left-hand side as viewed from the front) is at a higher level than Channel "B", and -dB when Channel "A" is smaller than Channel "B".

Once the signal level variations of the individual channels are known, the unit should be adjusted at a known point.

EXAMPLE: Assume that a highly accurate (±20 dB) ratio between the sum and difference of a monopulse antenna is to be measured over a given angle of rotation, and over this angle of rotation the sum signal which is connected to Channel "A" varies from -1 dB (near peak) to -10 dB and that the difference (Channel "B") channel varies from -30 dB to -5 dB over the same angle.

Since the sum varies 9 dB and the difference varies 25 dB over the range of interest or a total of 34 dB (which is within the display range of ±20 dB), the individual channels may be adjusted for this measurement.

Since Channel "B" as observed is within the desired operating range, the -30 dB angle point could be used as the set point. At this point, lower the signal level in Channel "A" by approximately 10 dB, at which time the ratio A/B should indicate +19 dB. As the antenna is rotated the ratio should be -15 dB at the other end point.

CHAPTER 4
THEORY OF OPERATION

4.1 GENERAL

The theory of operation of the Series 1833 Ratiometer is discussed on two levels; first, the overall operation of each of the two subsystems is discussed with reference to a simple block diagram. The functions of the two subsystems are then discussed in greater technical detail. In the detailed descriptions, the discussions are referenced to simplified schematic, timing, and waveform diagrams, as well as the schematic diagrams contained in Chapter 7. Common circuits and simple logic operations are not discussed; basic electronics and logic texts may be referred to for background in these areas.

All theoretical discussions in this chapter are given with the following assumptions:

a. The instrument is properly installed and operating.

b. Logic titles, used extensively in the technical descriptions, must not be confused with logic functions (such as the 'data gate' logic function); front panel control, indicator, or connector titles (the front panel GAIN control); or rear panel titles (the rear panel Input connector).

c. Logic titles (logic line titles) will always be overscored ($\overline{\text{OVERSCORED}}$) or underscored (<u>UNDERSCORED</u>) (for example, the <u>UNDERSCORED</u> line, or the $\overline{\text{OVERSCORED}}$ line).

d. An overscored logic title indicates a function determined by a negative level or transition, and an underscored logic title indicates a function determined by a positive level or transition. For example external triggering occurs when the $\overline{\text{EXT TRIG}}$ line makes a negative transition.

e. A logic "low" is defined as a diode-transistor logic (DTL) level at or near ground. A logic high is a condition during which the voltage level at a given point is forced to a positive voltage.

f. Positive logic is used throughout.

g. A component reference designation used within the text without a reference designator prefix describes a component in the circuit module being discussed; a specific indication will be given when referring to front or rear panel circuitry.

4.2 BLOCK DIAGRAM DISCUSSION

Two subsystems are contained within the instrument; the analog subsystem, and the digital subsystem. An overall block diagram of the instrument is shown in Figure 4-1. Other diagrams may be referenced within the subsystem discussions.

Both the Models 1833A-10 and 1833A-20 Ratiometers contain two identical analog channels. The Model 1833A-10 contains only one digital section; the Model 1833A-20 contains two identical digital sections.

4.2.1 ANALOG SUBSYSTEM DESCRIPTION

Since the channel A analog subsystem is identical to channel B only Channel A will be discussed.

Channel A analog subsystem is shown in a simplified block diagram in Figure 4-2. The analog subsystem provides conversion of the ac input voltage to a dc level proportional to the ac input level and its logarithm; this dc output is fed to the digital subsystem for conversion to visual readout and binary-coded decimal (BCD) outputs.

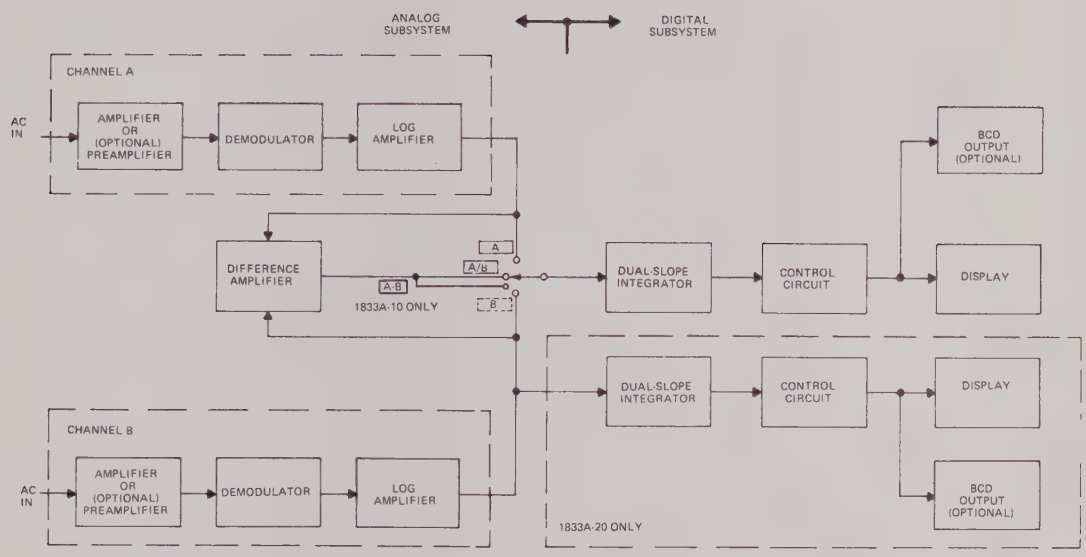


Figure 4-1. Ratiometer Simplified Block Diagram

The dc logarithm is also fed to a difference unit where the difference (ratio) and sum (product) between the log of the two channels is taken. Other outputs from the analog subsystem are:

a. A Bolo (bolometer) Current supply available for operation of a bolometer detector (optional).

b. An AC Output level proportional to the ac input level is available at the rear panel.

c. A DC Output level proportional to the ac input (or its logarithm is taken from the output of the lin/log amplifier and made available at the rear panel.

d. A DC Output level proportional to the logarithm difference and sum of channels A and B.

As shown in Figure 4-2, the input to channel A of the instrument is an ac signal level from a high level source or low level crystal bolometer detector at 1 kHz.* The optional preamplifier BOLO/XTAL switch selects the transformer T1 input appropriate for the detector used. From the secondary of T1, the input signal receives preamplification in the crystal/bolometer preamplifier. The preamplifier is a three-stage, variable-gain amplifier. A 30-Hz (bandwidth) filter filters the preamplifier output. The reference limiter amplifier and the synchronous demodulator receive this signal. The front panel CALIBRATE push-button switch allows the operator to provide a 10,000-to-1 attenuation of the input signal to the reference limiter amplifier and the synchronous demodulator through a resistive divider. Through a resistor, the ac signal applied to the synchronous demodulator is made available to the rear panel AC Out connector.

The reference limiter circuit supplies a constant-level ac reference to the synchronous demodulator. In addition to the input from the limiter, the synchronous demodulator receives an ac signal level analogous to the ac input level. Synchronous demodulation of the variable ac input is accomplished by changing the constant-level ac input to a square wave, then utilizing the square wave to full-wave rectify the variable ac input.

*1025 Hz for 50 Hz operation.

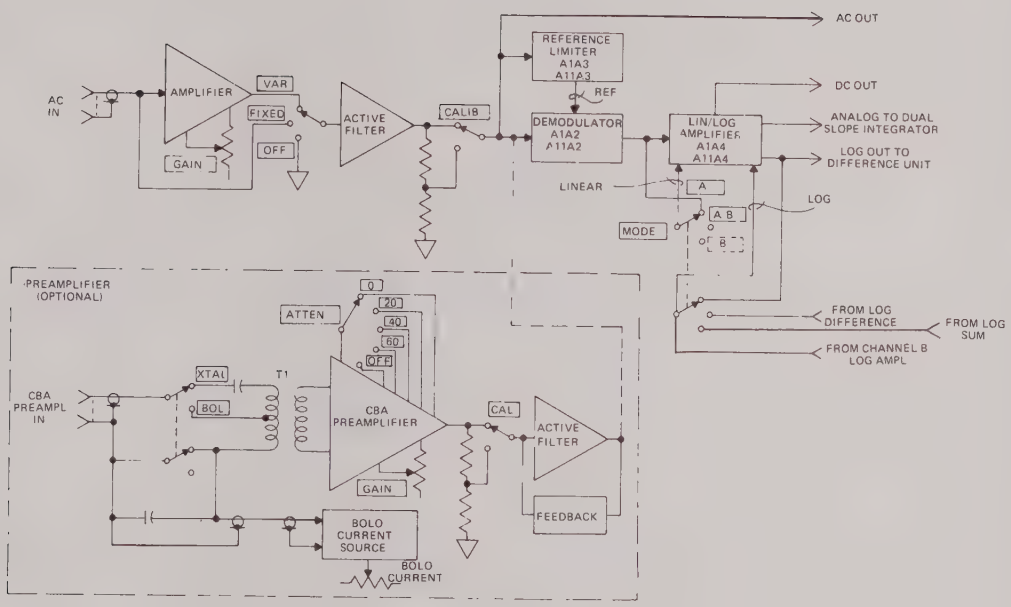


Figure 4-2. Analog Subsystem Block Diagram

The resultant dc output is provided to the lin/log amplifier, which supplies a dc output to the rear panel DC Out connector and to the digital subsystem. This dc level is either a linear or logarithmic function of the ac input level, as selected by the front panel DISPLAY RANGE switch. The dc log output of the lin/log amplifier is also provided to the difference circuit where the log difference and sum of channels A and B is obtained.

4.2.2 DIGITAL SUBSYSTEM DESCRIPTION

Comprising the digital subsystem are the interconnect and 6.4 MHz oscillator module, the dual-slope integrator module, the control logic module, and the display module. The highly versatile BCD output module (optional) provides buffered outputs from the digital circuitry to the rear panel for use by the external equipment.

The major circuits of the digital subsystem are shown in Figure 4-3. The dual-slope integrator ramps downward (to a negative voltage) and back upwards (to its positive voltage starting point). The comparator detects when the integrator has returned to the starting point. During the time the integrator is returning to its zero state (starting point), the control circuits allow the display counter to accumulate clock pulses.

The trigger and initiate circuits provide for internal or external control of the control circuits.

Should a range limit be exceeded, the digital display right hand decimals will blink and the 'out of range' output is energized.

The control counter is monitored by the control circuits. When a certain point is reached, the display counter is enabled and begins to accumulate data clock pulses. The sign polarity is detected and selected, causing the appropriate sign indicator lamp to light in the display.

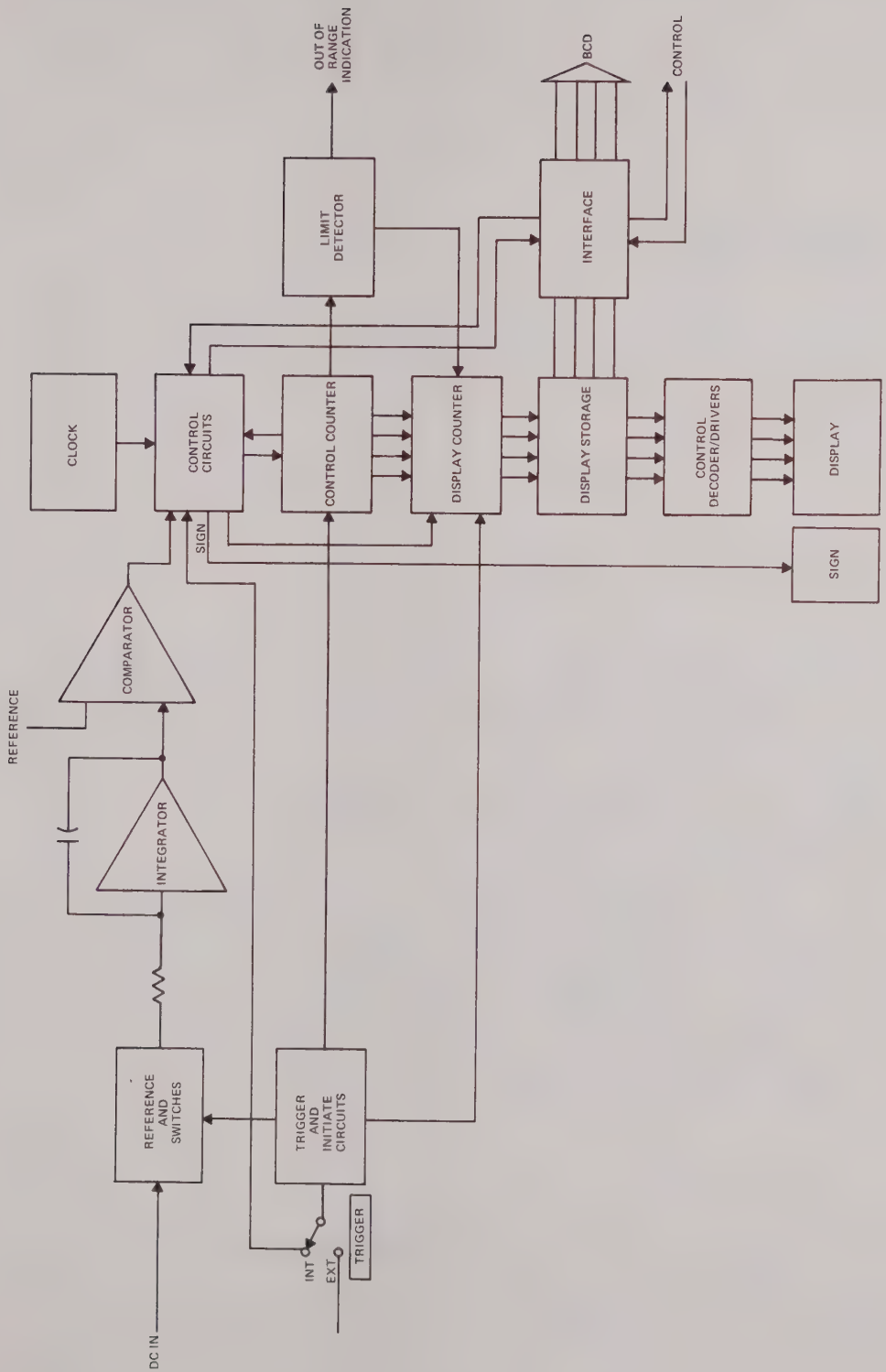


Figure 4-3. Digital Subsystem Block Diagram

When the measurement is completed, the BCD (binary-coded-decimal) information is transferred to the display storage. Both the BCD output and the decoder/drivers are driven by the display storage. The decoder/drivers change the BCD information to decimal information and drive the neon display indicators.

4.3 DETAILED DISCUSSION

Simplified schematic, timing, and block diagrams referenced in the following circuit discussions may be found in this chapter; schematic diagrams cited may be found in Chapter 7. The power supply is described in Paragraph 4.3.3.

4.3.1 ANALOG SUBSYSTEM DISCUSSION

Channel A of the analog subsystem consists of modules A1, A1A1 (optional), A1A2, A1A3, A1A4, A1A5, and A4. Channel B of the analog subsystem consists of modules A11, A11A1 (optional), A11A2, A11A3, A11A4, A11A5, and A14. These modules are described in the paragraphs that follow. The Channel A and Channel B modules are identical. Channel B reference designation prefixes are given in parenthsis.

Module A1 (A11) is a mother board on which are mounted the analog subsystem circuit boards, and interconnecting board A1A5 (A11A5) between the analog and digital subsystems. Connections to the rear panel connectors, controls, indicators, and the power supply are made with solder pads located on the mother board.

4.3.1.1 Input Amplifier, Active Filter, and Display Control Module A4 (A14). This module provides interconnection and amplification of the input signal and switch-selectable control of the range displayed.

Integrated circuit amplifier U1 (Figure 7-25), with associated frequency selective components connected between the R3 isolated output and the inverting input, forms a frequency-selective "tee" notch bandpass filter and input amplifier. The gain of the amplifier/filter is controlled by front panel GAIN control R3 or by internal gain adjustment potentiometer R11. With the front panel GAIN SEL switch in the VAR position, front panel GAIN control R3 is selected to adjust the gain of the input amplifier. In the FIXED position, the gain is predetermined by the adjustment of R11. The input amplifier/filter input signal is bypassed when the GAIN SEL switch is placed in the OFF position, and the inverting and non-inverting inputs of U1 are connected together through C7 and R12.

Resistor R9 determines the center frequency of the filter, while the bandwidth (Q) is adjusted with potentiometer R8. The front panel CAL pushbutton switch provides attenuation of the amplifier/filter output level by 80 dB when front panel screwdriver adjust potentiometer R4 (CAL) is properly adjusted.

The DISPLAY RANGE switch is used to control the digital and analog display control circuits to provide the proper display.

4.3.1.2 Crystal/Bolometer Preamplifier Module A4 (A14). Preamplifier A4 (A14), shown in Figures 7-27 and 7-29 receives its ac input from the secondary of transformer T1 which supplies the base of Q1. Q1 and Q2 form a variable-gain amplifier controlled by R3, the front panel GAIN control. From Q2, the signal is capacitively coupled through attenuator S1B to Q3, which, with Q4, forms a fixed-gain amplifier. C4 couples this output through attenuator S1C to fixed-gain amplifier Q5-Q6. The output of the preamplifier is supplied to the 1000-Hz (standard frequency) filter.

4.3.1.3 Active Filter/Bolometer Current Supply Module (A1A1 and A11A1). The active filter/bolometer current supply module is supplied as part of the preamplifier option (Option -2). The active filter is used to provide a 30-Hz bandpass filter action at the operating frequency normally 1000-Hz. The bolometer current circuit is completely independent of the filter and is used to provide bolometer current to an external bolometer (not part of the ratiometer) when used.

The signal input to the filter (Figure 7-1), is from preamplifier A4 (A14) to pin B, from which the signal is passed through an R-C network (C1-R1) which acts as a high-pass filter section, to the inverting input of U1. Between the output of U1 and its input is a "tee" notch filter that is tuned to operating frequency by R5. Resistor R19 is used to adjust the bandwidth (Q) of the filter. CR2 reduces the saturation effects of U1.

When a bolometer is used as the input signal source to the ratiometer, current to the bolometer is provided by Q1. The current level is determined by the setting of R12. R17 is provided to monitor the current from Q1.

To adjust the current to the bolometer the XTAL/BOLO switch on the preamplifier must be in the BOLO position, and the bolometer to be used connected to the input jack. By connecting a 20,000 ohm/volt voltmeter (Simpson 260 or equivalent) between TP4(+) and TP5 with the meter scale set to the 2.5V dc range adjust R12 for the desired current.

NOTE

The voltmeter reading is made across a 100 ohm resistor in series with the bolometer output current. The voltmeter will indicate 1 volt for each 10 mA of bolometer current.

4.3.1.4 Reference Limiter Module A1A3 (A11A3). Limiting amplifier U1 (Figure 7-9) receives the amplified and filtered signal from module A1A1 (if used) or from the amplifier on A4. CR1 and CR2 limit the output swing of U1 to approximately ±0.5V.

Capacitively coupled through C7 and R10, the output of U1 is applied to the input of U2, which is similar to amplifier U1. The output of U2 is coupled to active filter U3 through R15. The active filter is tuned to 1000 Hz by potentiometer R16. Since the output of U2 is limited to approximately ±0.5V and the gain of U1 and U2 can be as high as 120 dB, the output level from U2 remains at a stable level over a wide range of input level changes. The limiter output is taken from U3 and applied through R20 to the synchronous demodulator circuit as the reference signal.

4.3.1.5 Synchronous Demodulator Module A1A2 (A11A2). Two input signals are applied to the synchronous demodulator (Figure 7-7). They are the amplified and filtered ac input signal, which may vary in amplitude; and the constant level reference signal from the reference limiter circuit. The synchronous detector provides a dc level output proportional to its ac input.

C1 capacitively couples the filtered ac input signal to phase-splitting amplifier Q1. R6 and C2 form an adjustable phase-shift network so that the phase of the signal applied to amplifier Q2-Q3 may be adjusted to exactly match that of the reference limiter output. The output of this amplifier is applied to the primary of transformer T1.

The reference signal is applied to differential amplifier U1. CR3 and CR4 limit this signal such that a square wave is applied to the negative input of U1. The positive input is derived from an adjustable voltage divider through R18 to the wiper of R22, providing the positive input with a voltage adjustable in amplitude and polarity. The zero reference of the output of U1 may be varied to provide a symmetrical square wave at terminal 6 of U1. Q6 inverts the square wave output of U1 so that field-effect transistors Q4 and Q5 are driven to conduct on alternate half-cycles of the ac input. As the transistors alternately conduct, the ac signal applied to the primary is coupled through the transformer to provide a full-wave-rectified dc level at the center-tap of T1 that is proportional to the ac level applied to the primary. This output is fed to lin/log amplifier A1A4 (A11A4).

4.3.1.6 Lin/Log Amplifier Module A1A4 (A11A4). The lin/log amplifier operates in two modes, a linear mode and a logarithmic mode, they are described below (Reference Figure 7-11).

Linear Mode: When the DISPLAY RANGE switch is in the 100% position, the lin/log amplifier operates in the linear mode. With S1 set to 100%, log amplifier U1 is bypassed, and the dc input from the synchro-

nous detector is applied to U4 (positive input). U4 is a fixed-gain linear amplifier.

Feedback for U4 is controlled by the resistance network coupled back to the negative input of U4. R21 is the internal gain adjustment, and R15 is the zero calibration potentiometer. The output of the lin/log amplifier is routed through isolation resistor R19 to pin S, where it is supplied to the dual-slope integrator. The auxiliary dc output is available at rear panel connector J4 through isolation (protection) resistor R18.

Logarithmic Mode: When S1 is set to a position other than 100%, the logarithmic amplifier output (or its difference or sum as compared to the other channel) is switched into the circuit preceding the linear amplifie

The dc input signal from the synchronous detector is routed through summing resistor R1 to the negative input of U1. Feedback for this amplifier is controlled by U2 and R4 such that the output is the logarithm of the dc input signal. U2 is temperature controlled for minimum characteristic change due to environmental temperature changes. The output of U1 is a dc voltage which is supplied to U3 for amplification. The half of U2 connected as a diode is used to reference the output of U1 to zero. Zero calibration is provided by R6 and R7. Pin 1 of U1 is connected to a bias potentiometer (CALIBRATE) on the front panel for full-scale calibration capability. R8 in the feedback loop of U3 is used to set the output of the log amplifier to exactly 0.5V per 10 dB of signal change. The log zero bias potentiometer R12, develops a bias voltage applied to the offset null circuit of U3.

4.3.1.7 Difference Module A9. Two input signals are applied to the difference module (Figure 7-33). They are the dc log signals from Channel A and Channel B logging amplifiers and vary 0.5V dc per 10 dB of signal change. The Channel A signal is applied through gate transistors Q1 to the negative (inverting) input of the difference amplifier U5 or Q2 to the positive (non-inverting) input of difference amplifier U5. Likewise Channel B signal is applied through gate transistor Q4 to the positive input of U5 or through Q3 to the negative input of U5.

The output of difference amplifier U5 is provided to the MODE selector switch on the front panel and is switched into the circuit during ratio measurements. The input gates to U5 are controlled by Q5 and Q6 which are controlled from a R-S (reset, set) flip-flop (U6A and U6B). The position of the R-S flip-flop is determined by difference amplifier U2 through comparator amplifier U4. Comparator amplifiers U1 and U3 determine if Channel A or Channel B are out-of-range signals (either to high or low) during ratio (difference) measurements. Q7 and Q8 provide -6V and +12V for amplifiers U1 and U3.

Since the digital conversion subsystem uses only positive polarity signals and a true difference amplifier may have either a positive or negative output (depending on which input is larger), the difference unit detects which channel has the larger signal and switches the input to difference amplifier U5 if necessary to maintain a positive polarity output.

Differential amplifier U2 provides a true difference output between Channel A and Channel B input. The output of U2 is positive if the Channel A detected input signal is larger (the log dc input signal to the difference module is less positive than Channel B). An analog output from U2 through R16 is provided for external use if desired.

The output of U2 is compared in U4 to a hysteresis feedback voltage from U4 output. The hysteresis feedback in U4 is used to prevent the comparator from switching back and forth on noise when its input signal is approximately zero. When the input to U4 pin 2 is positive (Channel A is larger), its output at pin 6 is negative (clamped at a logic zero of approximately -0.5V dc by Q9). This logic zero signal passes through inverting amplifier U7C to NAND gate U6D and to NAND gate U6C. If a measurement is not in progress (pin 10 & 13 of U6 high), the signal passes through U6C and U6D and sets R-S flip-flop U6A and U6B with pin 6 high and pin 3 low. With pin 6 of U6 high, Q5 is turned off and its collector is at approximately -15V which turns gating transistors Q2 and Q3 off. At the same time Q5 is off, Q6 is turned on and its collector is connected to the 5V supply. This in turn turns Q1 and Q4 on, connecting Channel A input to the inverting side of difference amplifier U5 and Channel B to the non-inverting input of U5, providing a positive polarity difference output. If the Channel B input were

larger, the output of U2 would be negative, U4 output would be at a logic high level (approximately +5V dc), the R-S flip-flop would be reset (pin 3 high, pin 6 low) of U6, Q5 on, Q6 off, gate transistors Q1 and Q off, and Q2 and Q3 on, connecting the Channel A input to the non-inverting side of U5 and Channel B input to the inverting side of U5. Since Channel B is larger (Channel A log input more positive) the output of U5 should be positive and capable of being converted in the digital subsystem.

Amplifier U8 sums the channels A and B signals and provides unity gain. Its output, which is inverted, is then routed to another unity gain inverting amplifier, U9. This amplifier provides the Product (A·B) output to the front panel MODE switch. A second output on pin Y provides a dc voltage of .5 volts per 10 dB to the PFA output connector. Potentiometer R53 is used to zero the offset voltage and R54 is used for setting the gain.

During ratio measurements, the gate control sign from pin 3 of U6A is furnished to the digital subsystem where it is compared with the sign information of the digital circuit and allows the proper sign information to be displayed. When the Channel A input is larger than the Channel B input, a plus (+) sign is displayed, and when the Channel B input is larger than the Channel A input, a negative or minus sign (-) is displayed.

Since the output of the difference module is the difference between Channels A and B, either (or both) channels could be out-of-range and still the difference between the two signals could be in-range (0 to approximately 70 dB). Since this can occur, the Channel A input is monitored by comparator amplifier U1 and the Channel B input is monitored by comparator U3. Both circuits operate exactly the same; only Channel A is explained here. Channel A input varies 0.5V per 10 dB signal change with 0 dB being zero volts input and -80 dB being +4V.

This signal is divided by resistors R1 and R2 providing an input of 0 to +1 volt to U1. The reference input to the comparator (pins 3 and 6) is set by resistor R3 for approximately +0.9V and zero volts respectively. If the input voltage to pin 4 of U1 exceeds the voltage at pin 3, U1 output (pin 9) goes to a logic level high. This logic high causes inverting amplifier U7A pin 3 to go to a logic level low. When ratio measurements are being made, this logic low is connected through a front panel switch to the digital subsystem to provide out-of-range indication.

4.3.2 DIGITAL SUBSYSTEM

The Channel A digital subsystem consists of modules A1A5A1, A1A5A2, A2, and A3; these modules are described in the following paragraphs.

In the Model 1833A-20 (Dual Display), the Channel B digital modules are A11A5A1, A11A5A2, A12 and A13. These are identical to their respective A Channel modules.

Since much of the circuitry on dual-slope integrator module A1A5A2 (A11A5A2) interconnects with circuitry on control logic module A1A5A1 (A11A5A1), a thorough discussion of the combined operation of these two boards is given in Paragraph 4.3.2.3. The display modules A2 and A12 (Figure 7-19) each contain a neon display (DS1 through DS7), display decoder/drivers (U1 through U5), and switch transistors Q1 and Q2.

4.3.2.1 Control Logic Module A1A5A1 (A11A5A1). The control logic module (Figure 7-15) contains the control counter, IC3, IC7, IC11, and IC15; display counter, IC19A through IC22; display storage, IC23 through IC26; the limit detector, IC14B; and portions of the control circuitry, including the control counter (jump) circuit, IC2D, IC4C, and IC19B.

In addition to the control, data and storage for the basic analog-to-digital (A/D) converter out-of-range interface logic (U29D), and the sign interface logic (U27A, U27B, U27C, and U27D) are used during the ratio measurements. Unijunction transistor Q1 is used to set up a low cyclic variation to flash the right-hand decimal on the digital indicators (located on the display module) when out-of-range J-K flip-flop U28B is turned on.

4.3.2.2 Dual-Slope Integrator Module A1A5A2 (A11A5A2). The dual-slope integrator module (Figure 7-17), contains the integrator, IC14; the comparator, IC15, Q11, Q12; the signal, reference, and cage switching circuits, IC13A, IC3, IC4, and IC8; and the trigger and initiate circuitry, IC9C, IC9D, IC10A, IC10C, and IC12A.

4.3.2.3 Integrator and Control Logic Operation. The dual-slope integrator receives its name due to its integration of two voltages to and from a common reference point. From the time the trigger is applied until a reference time is reached, the dc voltage level or

ratio of the two channels is integrated. At the reference time the integrator has reached a voltage level representative of the dc input. The slope of this ramp is dependent upon the input voltage level. From the level reached, the integrator integrates a fixed reference until the starting voltage is reached. The second slope is constant; the time required to reach the starting point is directly proportional to the amplitude of the input signal.

The dc input signal to the integrator from the lin/log amplifier is applied to the integrator (IC14, Figure 7-17) through signal switch Q3. Signal switch Q3 is driven by switch driver Q6, which is controlled by the signal switch logic gate, IC13B. A front panel PERIOD switch (S2) selects one of the three capacitances -- C7, C8, or C9 -- for the feedback loop of the integrator.

A comparator, IC15, senses when the integrator has returned to its fixed starting voltage. The dc supply voltages applied to IC15 are stabilized by voltage divider regulators Q9 and Q10. Q11 and Q12 form a further comparator to provide the proper COMPARATOR signal for use by the digital circuitry on the control logic module.

The fixed reference voltage for the comparator and integrator circuitry is derived from temperature-compensated Zener diode CR1. Reference switch driver Q5, driven by the reference switch gate through inverter IC10D, controls the reference switch, Q2. Q2 switches the reference voltage into the integration system at the proper time for integration of the reference voltage.

In order to prevent drift of the comparator sensing point from affecting the output accuracy of the instrument, the comparator and integrator are operated as a closed-loop feedback amplifier to maintain the comparator in its active region when the integrator is in its 'cage' condition (i.e., when the integrator has returned to its starting voltage condition). Therefore, the integrator output always starts from the exact transition point of the comparator regardless of the level of the transition point. The transition point is nominally +8.5 volts. Diodes CR4 through CR8, and CR10 through CR12 are signal limiting diodes included to maintain the signal within acceptable limits at certain points.

The 6.4 MHz clock frequency, generated on the interconnect and 6.4 MHz oscillator module, is divided down by binary (divide-by-two) and decade (divide-by-ten) dividers IC8A, IC8B, IC3, and IC4.

The clock frequency at IC12B, pin 13, is selectable with the front panel PERIOD switch (S2B). The switch-selected clock frequency at this point is 1.6 MHz in the 0.01 (SECONDS) position; 160 kHz in the 0.1 (SECONDS) position; and 16 kHz in the 1 (SECONDS) position. The different clock frequencies permit integrator operation over similar voltage ranges for all PERIOD switch positions. Since the integrator and the clock are independent of each other, it is not important for the integration time-constant to change by an exact ratio of 10-to-1 for a clock frequency change of 10-to-1.

Inverters and gates IC1D, IC1E, IC2B, IC2C, and IC2D are used to select the appropriate clock rate for the display scale range being used. Timing within the system is established such that the following display counter accumulations will equal 10-volt (dc) input levels to the integrator in the DISPLAY RANGE settings listed:

DISPLAY RANGE SETTING	DISPLAY COUNTER ACCUMULATIONS	INPUT SIGNAL SCALE FACTOR
10	1000	1 dB/volt
20	2000	2 dB/volt
40	500	5 dB/volt
80	1000	10 dB/volt
100%	1000	10%/volt

With the front panel TRIGGER INT/EXT switch (S1) set to EXT, gate IC9C is enabled and trigger flip-flop IC12A may be set by a negative edge applied to the External Trigger input. Once IC12A is set, it will be unaffected by further changes on the External Trigger line until the completion of the measurement in progress. In the INT position, gate IC9D is enabled and applies 1.6 MHz pulses to the trigger flip-flop. Thus, as soon as IC12A is able to accept a trigger, it is retriggered. The instrument is thereby operated at its maximum cyclic rate when the INT trigger switch position is selected. When triggering occurs, pin 6 of the trigger flip-flop goes low, disabling monostable multivibrator (single-shot) IC7, and reset single-shot IC11 is triggered.

Also released from their initial starting conditions when triggering occurs are IC6A, IC6B, and IC12B through inverter IC10B. From IC11, a reset pulse lasting one control clock pulse period is applied to the $\overline{\text{RESET}}$ line. The trigger flip-flop (IC12A) is reset with an $\overline{\text{END OF CYCLE}}$ pulse applied to pin 4 when a measurement is completed.

As long as the trigger flip-flop is in the reset condition, update single-shot IC7 can be triggered if the $\overline{\text{UPDATE INHIBIT}}$ line is high. Therefore, in the INT TRIGGER position with the $\overline{\text{UPDATE INHIBIT}}$ high, the display will be updated immediately after a measurement, and since another measurement begins immediately, it cannot be updated at any other time.

In the EXT TRIGGER position, the display may be updated at any time that a measurement is not in progress. If the $\overline{\text{UPDATE INHIBIT}}$ line is low at the time the flip-flop resets, the display will not be updated until the $\overline{\text{UPDATE INHIBIT}}$ line goes high.

Gates IC13A, IC13B, and IC13C, and inverter IC10D perform the logic functions required to select the signal, reference, and cage switches at the appropriate times. The signal switch (Q3) is selected at the beginning of every measurement. The reference switch (Q5) is selected at the end of 5000 control counter accumulations, then the reference and cage (Q7) switches are both selected during the hold condition. The cage switch balances the reference input to keep the comparator at the transition point.

For the remainder of the integrator and logic control discussion, assume that the instrument is operating properly with the following front panel control settings (except where otherwise specified in the text).

Control	Setting
MODE	A
DISPLAY RANGE	20 dB
TRIGGER INT/EXT	INT
PERIOD-SECONDS	0.1
BOLO/XTAL	as appropriate
ATTENUATION, dB	as appropriate
GAIN	as appropriate
POWER	ON

When the integrator begins to ramp down, integrating the input voltage, the control counter is energized and begins to accumulate control clock pulses.

During the period the control counter is accumulating clock pulses, the LESS THAN 5000 line remains high until the 5000th clock pulse has been counted. At this time, the LESS THAN 5000 line goes low, disabling the signal switch gate (IC13B, Figure 7-17) on the integrator and the reference switch (IC13C) becomes enabled. This results in the integrator input being switched from the dc input level to the reference voltage level.

On the logic control board, the preset gate (IC4C, Figure 7-15) toggles preset flip-flop IC19B, which jumps the count from 5000 to 5600. The control counter will continue to accumulate control clock pulses until either the control counter reaches 6000 or the COMPARATOR line goes high. Should the COMPARATOR line go high prior to the counter reaching 6000, the ac input level to the instrument is a positive (+) dB level. If the control counter reaches 6000 first, the ac input is a negative (-) dB level. If the $\overline{\text{MAXIMUM MEASUREMENT IN PROGRESS ENABLE}}$ (or $\overline{\text{MMIP ENABLE}}$) line has been forced low through rear panel connector J5, pin D, the counter will count to its maximum count and begin the measurement process again. When the $\overline{\text{MMIP ENABLE}}$ line remains high, the measurement time periods will vary slightly, depending on the amplitude of the input signal level.

In the case of an internal trigger, positive dB input, maximum measurement time measurement, the COMPARATOR line will go high before the control counter reaches 6000. Figure 4-4 shows a timing diagram for a measurement such as this. For specific component references, see also Figures 7-15 and 7-17.

Prior to t_0, the digital circuitry has been reset and returned to a pre-measurement condition. At time t_0, a trigger pulse (1) is generated internally, initiating a measurement. The control clock is enabled, passing control clock pulses to the control counter (2). The signal switch gate is enabled (4), allowing the dual-slope integrator (6) to ramp downward. At 1000 counts, gate IC5B (Figure 7-15) resets the data latch, IC18A and IC13D. D (data) lamp switch Q2 (Figure 7-19) on the display module is enabled and the D (data) lamp is extinguised. When the control counter accumulates 5000 counts (t_1), preset gate IC4C (Figure 7-15) is enabled, triggering the preset (or jump) flip-flop,

IC19B. The preset flip-flop is toggled, passing a level change to the strobe input of the third-digit decade, IC7, which jumps from "0" to "6". At the same time the counter is jumped (t_1), the signal switch gate (4) is disabled, and the reference switch gate (5) is enabled by the LESS THAN 5000 line (3) going low. The integrator (6) now ramps back to its starting voltage level by integrating the reference voltage generated by Zener diode CR1. When the integrator reaches its level (t_2), the COMPARATOR line (8) of the integrator board goes high and the cage switch (9) is enabled.

Since the ac input voltage measured in this case is a positive (+) dB level, the COMPARATOR line (8) and the data gate IC2C line go high before the jumped-count control counter (7) reaches 6000 (t_3). IC2B sets the signal flip-flop (IC18B, IC18D) to the plus condition at time (t_2). When the data gate (10) goes high, the data clock pulses (11) are gated through IC2A to IC2B on the integrator board to the display counter on the logic control board. The display counter accumulates data clock pulses until the control counter reaches 6000 (actually 6001) (7), at which time the data gate (10) is disabled (t_3), preventing the data clock pulses from reaching the display counter.

1. Trigger
2. Control counter accumulations -- actual
3. LESS THAN 5000
4. Signal switch gate
5. Reference switch gate
6. Integrator (stylized waveform)
7. Control counter accumulations
8. Comparator line
9. Cage switch gate
10. DATA GATE
11. Data clock enabled -- display counter accumulations
12. END OF CYCLE
13. Update
14. Reset

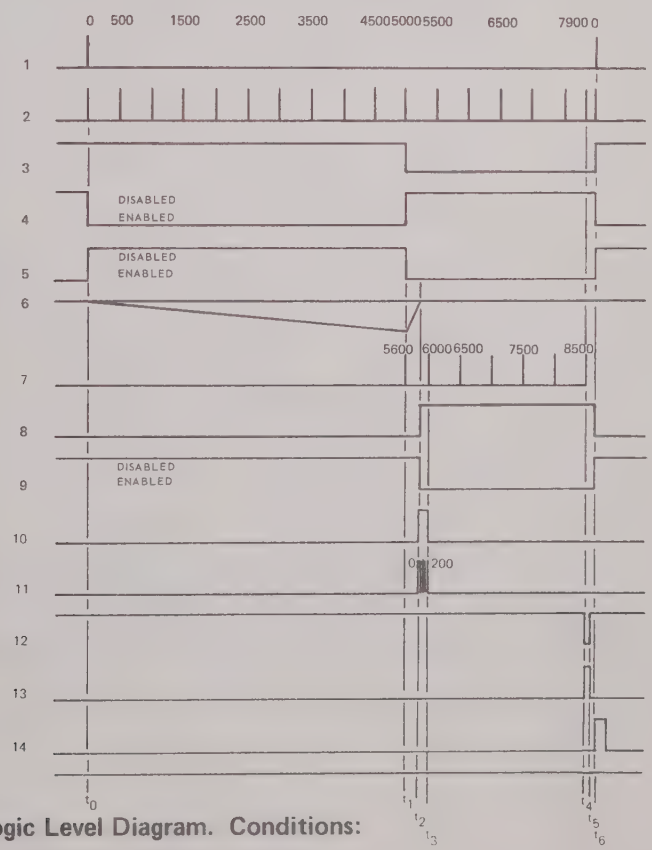


Figure 4-4. Simplified Logic Level Diagram. Conditions: Internal Trigger, +dB Input, Maximum Measurement

The count of 6000 is detected by IC4D by the "1's" outputs of IC15 and IC3 triggering IC1B, which may be triggered only after IC1B is enabled at 5000 counts.

The control counter continues to accumulate pulses until a jumped count of 8500 is reached (t_4). Gates IC4A, IC4B, and IC9A detect a control counter accumulation of 8500 and, with IC14A, cause the $\overline{\text{END OF CYCLE}}$ line (12) to go low.

When the $\overline{\text{END OF CYCLE}}$ line (12) at the dual-slope integrator goes low (t_4), trigger flip-flop IC12A is reset, IC12A pin 5 goes low, locking the integrator in its cage condition at IC13B and IC13C. The cage condition is defined as the outputs from the cage switch gate (9) low, the reference switch gate (5) low, and the signal switch gate (4) high.

IC12A pin 6 goes high when pin 5 goes low, and through IC10B, prevents data clock pulses from reaching the data clock gates (by resetting IC6A and IC6B), and stops IC12B when toggled into the zero condition (pin 12 goes low) at the end of the next control clock pulse. IC12B pin 9 goes low and resets IC14A on the control logic board, clearing the $\overline{\text{END OF CYCLE}}$ pulse (12) (IC14A pin 6 goes high).

Also, when the dual-slope integrator board trigger flip-flop (IC12A pin 6) is toggled high, the update single-shot function (IC7A and IC7B) is triggered if the $\overline{\text{UPDATE INHIBIT}}$ line is high. The $\underline{\text{UPDATE}}$ line (13) goes high (t_4) to (t_5) and the storage latches (IC23 through IC26) are updated. This updated information is passed on to the display decoder drivers (U1 through U5) located in the display module.

When the integrator board trigger flip-flop resets (t_8), IC9B pins 4 and 5 go high. With both inputs to IC9B high, the $\overline{\text{MIP}}$ line to external equipment goes high again through IC10F.

When the system is retriggered (t_0) by IC9D toggles, pin 6 goes low, and single-shot function IC11A and IC11B is triggered, the RESET line (14) goes high and resets the logic control board gates and counters. The instrument then begins another measurement when the first control clock pulse occurs.

If the MAXIMUM MEASUREMENT IN PROGRESS ENABLE ($\overline{\text{MMIP ENABLE}}$) line is high, the instrument will operate at its maximum cyclic rate. In the case of an internal trigger, positive dB input, variable time measurement, the COMPARATOR line will go high before the control counter reaches 6000. The following discussion is for the case described above. Figure 4-5 shows a timing diagram for this discussion; for specific component references, see also Figures 7-15 and 7-17.

Prior to t_0, the digital circuitry has been reset and returned to a pre-measurement condition. The internally generated trigger pulse (1) occurs at time t_0, initiating a measurement. The control clock is enabled, allowing control clock pulses to reach the control counter (2). Signal switch gate (IC13B, Figure 7-17) is enabled (4), allowing the dual-slope integrator (6) to ramp downward. At 1000 counts, gate IC5B (Figure 7-15) resets the data latch, IC18A and IC13D. D (data) lamp switch Q2 on the display module is enabled and the lamp is extinguished. When the control counter accumulates 5000 counts (t_1), preset gate IC4C (Figure 7-15) is enabled, triggering the preset (or jump) flip-flop, IC19I The preset flip-flop is toggled, passing a level change to the strobe input of the third-digit decade, IC7, which jumps from "0" to "6". At the same time the counter is jumped (t_1), the signal switch gate (4) is disabled, and the reference switch gate (5) is enabled by the LESS THAN 5000 line (3) going low. The integrator (6) now ramps back to its starting voltage level by integrating the reference voltage generated by Zener diode CR1. When the integrator reaches its starting voltage level (t_2), the COMPARATOR line (8) of the integrator board goes high, and the cage switch is enabled.

1. Trigger
2. Control counter accumulations -- actual
3. LESS THAN 5000
4. Signal switch gate
5. Reference switch gate
6. Integrator (stylized waveform)
7. Control counter accumulations -- jumped count (first jump)
8. Comparator line
9. Cage switch gate
10. Data gate
11. Display counter accumulations (data clock enabled)
12. Control counter accumulations -- jumped count (second jump)
13. END OF CYCLE
14. Update
15. Reset

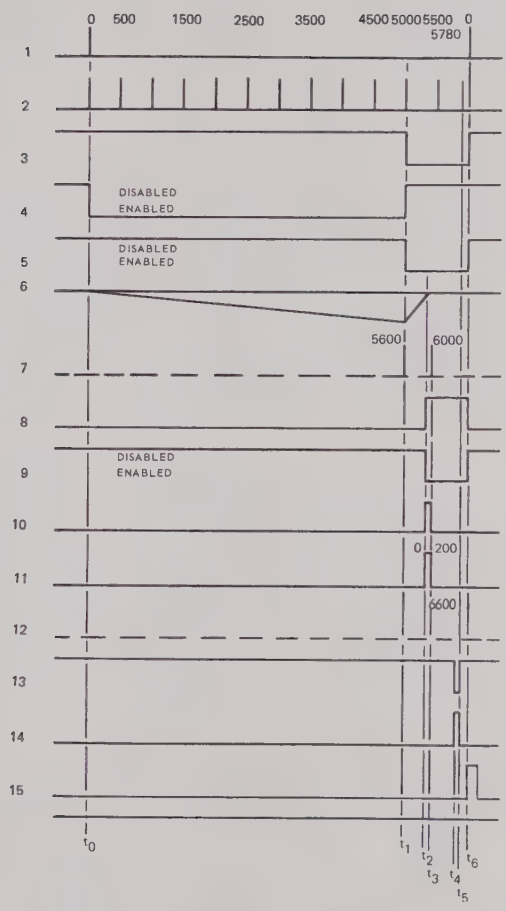


Figure 4-5. Simplified Logic Level Diagram. Conditions: Internal Trigger, +dB Input, Variable Measurement Time

Since the ac input voltage measured in this case is a positive (+) dB level, the COMPARATOR line (8) goes high before the jumped-count control counter (7) reaches 6000 (t_3). The data gate IC2C output goes high and IC2B sets the sign flip-flop to the plus condition at this time (t_2). When the data gate (10) goes high, the data clock pulses (11) are gated through IC2 on the integrator board to the display counter on the logic control board. The display counter accumulates data clock pulses until the control counter reaches 6000 (actually 6001) (7), at which time the data gate (10) is disabled (t_3), preventing more data clock pulses from reaching the display counter.

The count of 6000 is detected by IC4D (Figure 7-15) by the "1's" outputs of IC15 and IC3 triggering IC1B, which may be triggered only after IC1B is enabled after 5000 counts.

When the data gate (IC2C) on the logic control board returns low (10) (t_3) again, gate IC4C Pin 9 input is switched, toggling IC19B which strobes the preset inputs of IC7. Strobing IC7 will cause IC7 to jump to its preset input, and the number "6" will replace the number "0" in the third digit of the control counter (12). The control counter has now been strobed twice, and indicates 6600 or 1200 more than have actually occurred (5400).

Gate IC9A detects a control counter jumped accumulation of 6980 pulses and generates an $\overline{\text{END OF CYCLE}}$ line (13) transition low.

When the $\overline{\text{END OF CYCLE}}$ line (13) at the dual-slope integrator goes low (t_4), trigger flip-flop IC12A is reset, IC12A pin 5 goes low, locking the integrator in its cage condition at IC13B and IC13C. The cage condition is defined as the outputs from the cage switch gate (9) low, the reference switch gate (5) low, and the signal switch gate (4) high. IC12A pin 6 goes high when pin 5 goes low, and through IC10B, prevents data clock pulses from reaching the data clock gates (by resetting IC6A and IC6B), and stops IC12B when toggled into the zero condition (pin 12 goes low) at the end of the next control clock pulse cycle. IC12B pin 9 goes low and resets IC14A on the control logic board, clearing the $\overline{\text{END OF CYCLE}}$ pulse (13) (IC14A pin 6 goes high).

1. Trigger
2. Control counter accumulations – actual
3. LESS THAN 5000
4. Signal switch gate
5. Reference switch gate
6. Integrator (stylized waveform)
7. Control counter accumulations – jumped count
8. Comparator line
9. Cage switch gate
10. Data gate
11. Display counter accumulations (data clock enabled)
12. END OF CYCLE
13. Update
14. Reset

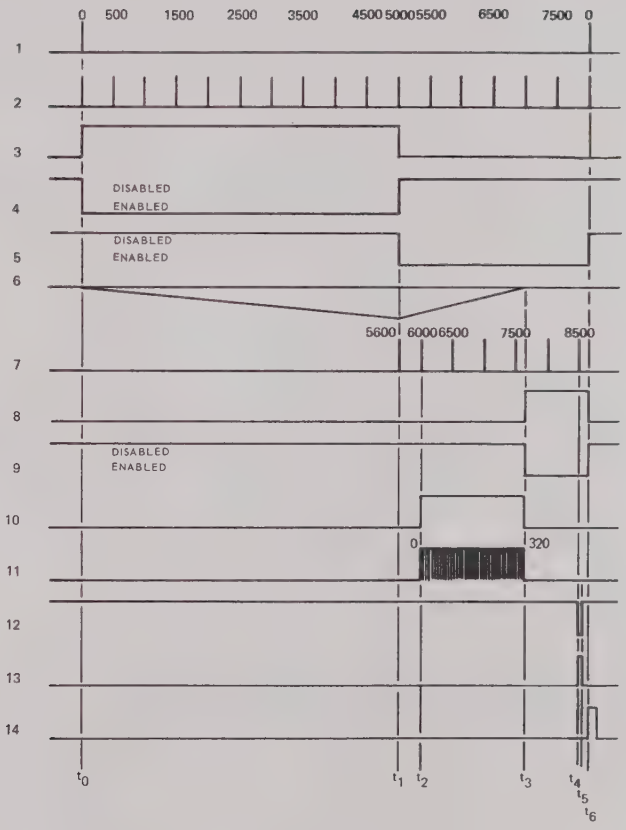


Figure 4-6. Simplified Logic Level Diagram. Conditions: Internal Trigger, - dB Input, Maximum Measurement Time

Also, when the dual-slope integrator board trigger flip-flop (IC12A Pin 6) is toggled high, the update single-shot function (IC7A and IC7B) is triggered if the $\overline{\text{UPDATE INHIBIT}}$ line is high. The $\overline{\text{UPDATE}}$ line (14) goes low (t_4), and the storage latches IC23 through IC26 (Figure 7-15) are updated.

When the integrator board trigger flip-flop resets (t_4), IC9B pin 5 goes high. With both inputs to IC9B high, the $\overline{\text{MIP}}$ line to the external equipment goes high again through IC10F.

When the system is retriggered, IC12A toggles, pin 6 goes low, and single-shot function IC11A and IC11B is triggered, the RESET line (15) goes high and resets the display board gates and counters.

Another measurement cycle is begun immediately with the generation of another trigger pulse.

Over most of the range of the input signal, the input to the integrator will be a negative dB level representation, in which case the COMPARATOR line will go high sometime after the control counter jumped accumulation reaches 6000. With an internal trigger, negative dB input, maximum measurement time measurement, the following discussion describes the operation of the instrument. Refer to the timing diagram, Figure 4-6 and the schematic diagrams, Figures 7-15 and 7-17.

As in the case of positive (+) dB inputs, the digital circuitry is reset and in a premeasurement state prior to t_0. At t_0, a trigger pulse (1) initiates the measurement. The control clock is enabled, passing control clock pulses to the control counter (2). The signal switch gate (4) is enabled at t_0, allowing the dual-slope integrator (6) to ramp downward. At 1000 counts, gate IC5B (Figure 7-15) resets the data latch, IC18A and IC13D. D (data) lamp switch Q2 on the display is enabled and the lamp is extinguished. At t_1, the LESS THAN 5000 (3) line goes low, disabling the signal switch (4) and enabling the reference switch (5). Preset gate IC4C is enabled, triggering the preset (or jump) flip-flop, IC19B. The preset flip-flop is toggled, passing a level change to the strobe input of the control counter third-digit decade, IC7, which jumps from "0" to "6" (7).

The control counter continues counting up from its jumped count (5600) until 6000 is detected by IC4D. Gates IC2A, IC2C, and IC4D, with flip-flop IC1B, enable the data gate (10), allowing data clock pulses to enter the display counter (11). The display counter accumulates data clock pulses until the integrator (6) returns to its starting point (t_3), when the cage switch enables (9), and the integrator board COMPARATOR line goes high, which disables the data gate (10) and stops the data clock output (11). The number stored in the display counter at this time is in direct proportion to the dc input to the dual-slope integrator. The plus sign driver on the display module Q1 is disabled, lighting DS6, the minus sign.

The control counter continues accumulating control clock pulses until a jumped count of 8500 (7900 actual counts) is reached (t_4). At this time, gates IC 4A, IC4B, and IC9B detect a jumped control counter accumulation of 8500 and, with IC14A, causes the $\overline{\text{END OF CYCLE}}$ line (12) to go low.

When the $\overline{\text{END OF CYCLE}}$ line (12) at the dual-slope integrator goes low (t_4), trigger flip-flop IC12A is reset, IC12A pin 5 goes low, locking the integrator in its cage condition at IC13B and IC13C. The cage condition is defined as the outputs from the cage switch gate (9) low, the reference switch gate (5) low, and the signal switch gate (4) high.

IC12A pin 6 goes high when pin 5 goes low, and through IC10B, prevents data clock pulses from reaching the data clock gates (by resetting IC6A and IC6B), and stops IC12B when toggled into the zero condition (pin 12 goes low) at the end of the next control clock pulse cycle. IC12B pin 9 goes low and resets IC14A on the control logic board, clearing the $\overline{\text{END OF CYCLE}}$ pulse (12) (IC14A pin 6 goes high).

Also, when the dual-slope integrator board trigger flip-flop (IC12A pin 6) is toggled high, the update single-shot function (IC7A and IC7B) is triggered if the $\overline{\text{UPDATE INHIBIT}}$ line is not low. The $\overline{\text{UPDATE}}$ line (13) goes low (t_4) and the storage latches (IC23 through IC26) are updated.

When the integrator board trigger flip-flop resets (t_4), IC9B pin 5 goes high. With both inputs to IC9B high, the $\overline{\text{MIP}}$ line to the external equipment goes high again through IC10F.

When the system is retriggered, IC12A resets, pin 6 goes low, and single-shot function IC11A and IC11B is triggered, the RESET line (14) goes high and resets the display board gates and counters. The instrument then begins another measurement when the first control clock pulse occurs.

If the $\overline{\text{MAXIMUM MEASUREMENT IN PROGRESS ENABLE}}$ ($\overline{\text{MMIP ENABLE}}$) line is high the instrument will operate at its maximum cyclic rate. In the case of an internal trigger, negative dB input, variable time measurement, the COMPARATOR line will go high after the control counter reaches 6000. The following discussion is for the case described above. Figure 4-7 shows a timing diagram for this discussion; for specific component references, see also Figures 7-15 and 7-17.

As in the case of the previous discussions, the digital circuitry is reset and in a premeasurement state prior to t_0. At that time, a trigger pulse (1) initiates the measurement. The control clock is enabled, passing control clock pulses to the control counter (2). The signal switch gate (4) is enabled (at t_0), allowing the dual-slope integrator (6) to ramp downward. At 1000 counts, gate IC5B resets the data latch, IC18A and IC13D. D (data) lamp switch Q2 (on the display module) is enabled and the lamp is extinguished. At t_1, when the control counter reaches 5000, the LESS THAN 5000 (3) line goes low, disabling the signal switch gate (4) and enabling the reference switch gate (5). The integrator now ramps back to its starting voltage level by integrating the reference voltage generated by Zener diode CR1. Preset gate IC4C is enabled, triggering the preset (or jump) flip-flop, IC19B. The preset flip-flop is toggled, passing a level change to the strobe input of the control counter third-digit decade, IC7, which jumps from "0" to "6" (7).

1. Trigger
2. Control counter accumulations -actual
3. LESS THAN 5000
4. Signal switch gate
5. Reference switch gate
6. Integrator (stylized waveform)
7. Control counter accumulations -- jumped count (first jump)
8. Comparator line
9. Cage switch gate
10. Data gate
11. Display counter accumulations
12. Control counter accumulations -- jumped count (second jump)
13. END OF CYCLE
14. Update
15. Reset

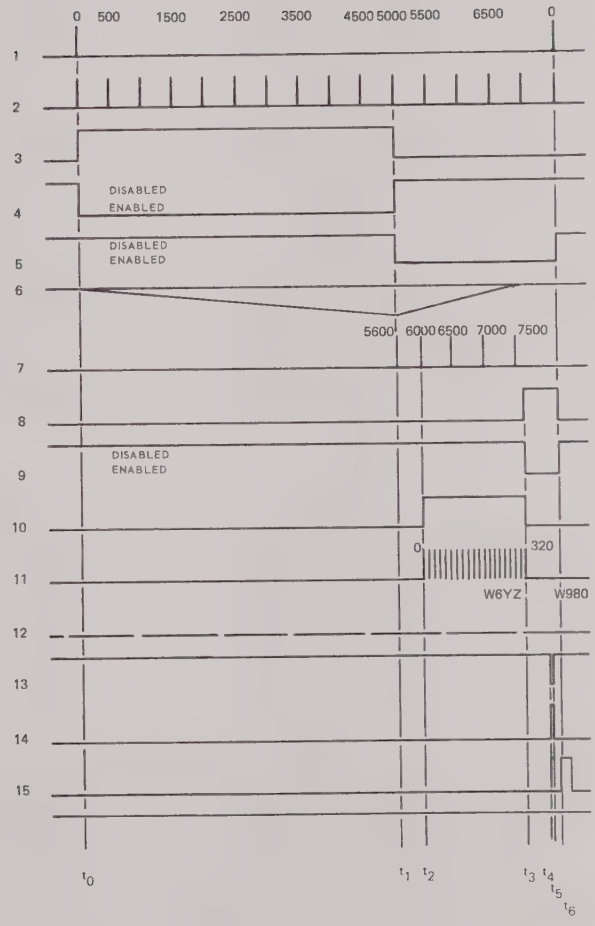


Figure 4-7. Simplified Logic Level Diagram. Conditions: Internal Trigger, -dB Input, Variable Measurement Time

The control counter continues counting up from its jumped count of 5600 until 6000 is detected by IC1B. Gates IC2A, IC2B, and IC4D, with flip-flop IC1A and IC1B, enable the data gate (10), allowing data clock pulses to enter the display counter (11). The display counter accumulates data clock pulses until the integrator (6) returns to its starting point (t_3), when the reference switch is disabled (5), the cage switch enabled (9), and the integrator board COMPARATOR line goes high (8). IC1A changes state when the display board COMPARATOR line goes high, which disables the data gate (10) and stops the data clock output (11). The number stored in the display counter at this time is in direct proportion to the dc input to the dual-slope integrator. Plus sign driver Q1 is disabled, lighting DS6, the minus sign.

When the data gate (IC2C) on the control logic board returns low (10) (t_3) again, gate IC4C, pin 9 (input) is switched, toggling IC19B which strobes the preset (jump) inputs of the control counter third-digit decade, IC7, which jumps from "0" to "6" again (12). The control counter has now been strobed twice, and indicates 1200 more counts than have actually occurred.

The time at which the integrator returns to zero (t_3) may be represented by the function WXYZ, where W is the number stored in the fourth digit of the control counter, X the number in the third digit, Y the number in the second digit, and Z the number in the first digit. The fourth digit (W) will contain either a six or a seven, while the others may be any number. At time t_3, the control counter indicates W6YZ. The control counter again continues accumulating control clock pulses until the number W980 is detected by gate IC9A. At this time, IC14A is toggled and generates an $\overline{\text{END OF CYCLE}}$ line transition low.

When the $\overline{\text{END OF CYCLE}}$ line (13) at the dual-slope integrator goes low (t_4), trigger flip-flop IC12A is reset, IC12A pin 5 goes low, locking the integrator in its cage condition at IC13B and IC13C. The cage condition is defined as the outputs from the cage switch gate (9) low, the reference switch gate (5) low, and the signal switch gate (4) high.

IC12A pin 6 goes high when pin 5 goes low, and through IC10B, prevents data clock pulses from reaching the data clock gates (by resetting IC6A and IC6B), and stops IC12B when toggled into the zero condition (pin 12 goes low) at the end of the next control-clock pulse cycle. IC12B pin 9 goes low and resets IC14A on the control logic board, clearing the $\overline{\text{END OF CYCLE}}$ pulse (13) (IC14A pin 6 goes high).

Also, when the dual-slope integrator board trigger flip-flop (IC12A pin 6) is toggled high, the update single-shot function (IC7A and IC7B) is triggered if the $\overline{\text{UPDATE INHIBIT}}$ line is high. The $\overline{\text{UPDATE}}$ line (13) goes high (t_4), and the storage latches (IC23 through IC26) are updated.

When the integrator board trigger flip-flop resets (t_4), IC9B pin 5 goes high. With both inputs to IC9B high, the $\overline{\text{MIP}}$ line to the external equipment goes high again through IC10F.

When the system is retriggered, IC12A resets, pin 6 goes low, and single-shot function IC11A and IC11B is triggered, the RESET line (15) goes high and resets the display board gates and counters. The instrument then begins another measurement when the next control clock pulse occurs.

4.3.2.4 BCD Output Card (Option -1) A3 (A13). Module A3 and A13 (Figure 7-23) was designed as a separate card to provide a flexible method of interfacing with systems with a minimum of modification to the system or to the display itself. The interface card buffers the outputs of the BCD storage (quad latches) such that external circuitry can in no way affect the operation of the display itself. The power supply connections to the output buffers are isolated from the power supply connections on the input buffers of the module. This is done so that on special order the user may supply voltage levels other than 5 volts to the output stages on the module.

4.3.2.5 BCD Byte Output Card (Option -4) A3 (A13). This module is designed as a separate card to provide a method of interfacing the data output with systems that have the capability of asking and accepting 8 bits of byte input.

As shown in Figure 7-21, BYTE 1 provides the two least significant digits of information when pin 22 is grounded, and BYTE 2 provides the remaining information - including the sign, decimal and out-of-range information when pin 23 is grounded. The outputs can be paralleled with up to two additional units.

4.3.2.6 Interconnect and 6.4 MHz Oscillator Module A1A5 and (A11A5). The interconnect and 6.4 MHz oscillator board provides interconnection between the analog and digital subsections of the instrument.

The 6.4 MHz basic clock frequency is generated on this module (Figure 7-13). U1A is a modified Colpitts oscillator, the coupling provided by L1. U1B comprises a buffer amplifier to shape and isolate the oscillator from loading.

4.3.3 POWER SUPPLY CIRCUITS (A10)

The ac input components of the power supply (see Figure 7-34) are located on the main chassis with connections provided to the analog and digital converter mother board through solder pads. Four supply voltages are required for the ratiometer; +250 volts for the neon indicators, +5 volts for the integrated circuits, and +15 and -15 volts for the conventional semiconductor circuitry.

4.3.3.1 ±15 Volt Power Supply A10A1. The ±15 volt power supply module (see Figure 7-36) A10A1, consists of full-wave bridge rectifier CR1 through CR4, filter capacitors C1 and C4, and + and - 15 volt regulators (described below).

±15 Volt Regulator. Integrated circuit regulators with external pass transistors are utilized in the ±15 volt supply. The external pass transistors are heat-sunk for greater current-carrying capability. Both the + and -15 volt regulators are interconnected by R6 to allow adjustment of both output voltages simultaneously with potentiometer R7.

Resistors R2, R3, and R4 provide foldback current limiting of the positive supply. Current limiting occurs when the voltage rise from pin 8 to pin 1 of IC1 is a nominal 0.39 volt. This condition, when the +15 volt dc output is shorted, occurs at approximately 0.78 amperes, but a nominal 1.08 amperes can be supplied under normal operating conditions.

Resistors R9, R10, and R11 serve as the current sensing resistors for the negative voltage regulator, IC2. The current limit voltage is a nominal 0.66 volt rise from pin 5 to pin 6 on IC2. The negative supply is capable of supplying 0.82 ampere (shorted) and 1.1 amperes (non-shorted) at normal operating conditions.

4.3.3.2 +5 Volt Power Supply A10A2. The +5 volt power supply, shown in Figure7-38, provides the operating voltages for most of the integrated circuits in the instrument. It is a conventional full-wave rectified dc supply with a series emitter-follower regulator. The reference voltage is derived from the +15 volt supply through voltage divider R1, R2, and R3. Q2 drives the regulator transistor, Q3 is located on the sink at the rear of the chassis.

4.3.3.3 +250 Volt Power Supply A10A2. The digital neon indicators are supplied 250 volts from this supply (see Figure7-38). A conventional half-wave rectifier supply is used, consisting of CR1 and C2.

CHAPTER 5
MAINTENANCE

5.1 GENERAL

Due to proven circuit design and use of highly reliable components, maintenance of Series 1833A Logarithmic Ratiometers has been largely limited to regular cleaning and inspection. Discussions relative to semiconductor maintenance, instrument troubleshooting, and alignment have been included should malfunctions occur.

5.2 VISUAL INSPECTION

Periodically, the instrument should be inspected as follows:

a. Disconnect ac power and remove the cover from the unit.
b. Inspect all wiring and cables for frayed, loose, or burned wires.
c. Check all cable connections, making sure the plugs are free from corrosion and are properly secured.
d. Check all components for evidence of overheating, breakage, vibration damage, corrosion, or loose connections.
e. Check capacitors and transformers for leaks, bulges, etc. (as appropriate).

5.3 CLEANING

The following procedure should be followed when cleaning the instrument during the course of maintenance operations:

a. Disconnect ac power. Using a clean, lint-free cloth lightly moistened with an approved cleaning solvent, remove foreign matter from the case and front panel of the instrument. Wipe dry using a clean, dry, lint-free cloth.

b. Using a hand-controlled dry-air jet (not more than 15 lbf/in^2), blow the dust from inaccessible areas. Care should be taken to prevent damage by the air blast.
c. Clean the electrical contacts of the connectors with a burnishing tool and/or cloth lightly moistened with an approved contact cleaner.
d. Clean the internal receptacles and printed circuit board contact "fingers" with a hand-controlled dry air jet (not more than 15 lbf/in^2), and a clean, lint-free cloth lightly moistened with an approved cleaning solvent. Wipe dry with a clean, dry, lint-free cloth.

5.4 SEMICONDUCTOR MAINTENANCE

Never remove or replace a semiconductor or circuit board containing semiconductors with the supply voltage turned on. Transients thus produced may damage semiconductors or other components remaining in the circuit. If a semiconductor is to be evaluated in an external circuit, take appropriate precautions to ensure the normal ratings of the semiconductor are not exceeded.

Use only low-heat soldering equipment when installing or removing soldered-in semiconductors. When removing a soldered-in semiconductor from a printed circuit board, first unbend the crimped leads. Use only the necessary amount of heat to unsolder the semiconductor. Clear excess solder from the mounting holes or eyelets before installing the replacement.

The use of a heat sink (such as a pair of pliers) is recommended, if practical, to dissipate some of the heat when installing or removing a semiconductor. Excessive heat may damage the semiconductor. In some cases, power transistors may be mounted on and insulated from heat sinks.

Often, this insulation is accomplished by means of insulating washers made of fiber or mica. When replacing transistors mounted in this manner, be sure that the insulating washers are replaced in the proper order. Mica washers are frequently coated with a film of silicone grease when initially installed. Before reinstalling such mica washers, coat them with a thin film of silicone grease to help transfer the heat generated. After the transistor is mounted and before any connections are made, check the insulation by measuring the dc resistance from the case of the transistor to the mounting plate. Only open circuit readings are acceptable.

5.5 MAINTENANCE EQUIPMENT

Table 5-1 lists the maintenance equipment required for efficient maintenance of the instrument. Items of equipment equivalent to those listed may be substituted.

TABLE 5-1. MAINTENANCE EQUIPMENT

Equipment	Manufacturer	Model
Volt-Ohm-Milliammeter, 20K-ohm/volt (dc)	Simpson	260
Sine-wave Generator, 1 kHz, high short-term output level stability	Hewlett-Packard	651B
Oscilloscope, dual-trace, 50-MHz bandwidth	Tektronix	547 with 1A1 plug-in
Attenuators, calibrated, 80-dB range (min), 0.1-dB accuracy at 1 kHz	Kay	100
Digital Voltmeter, 1-millivolt resolution, 10 volts full-scale (min)	Fairchild	7000
Miscellaneous Hand Tools, including:		
Screwdriver, small, flat-blade	--	--
Screwdriver, Phillips head, #1	--	--
Wrench, 9/16", open-end or box-end	--	--

5.6 GENERAL TROUBLESHOOTING

A general knowledge of the theory of operation and of the operating procedures (Chapters 3 and 4) is required for efficient troubleshooting of the instrument. The following procedure is recommended for general troubleshooting.

WARNING

HAZARDOUS VOLTAGES MAY BE EXPOSED DURING TROUBLESHOOTING OF THE INSTRUMENT. PERSONNEL ARE ADVISED TO EXERCISE DUE CAUTION TO PREVENT PERSONAL INJURY.

CAUTION

Remove ac power from the instrument before attempting to remove or insert the printed circuit boards as damage to the components may result. Avoid dropping metallic objects into the circuitry. Exercise care in attaching test probes.

a. Determine that an equipment trouble actually exists. Check for faulty operation of related equipment. Try to operate the display in the affected mode or range of operation.
b. Isolate the portion of the instrument that is not functioning properly through simple tests and deductive reasoning.
c. Determine the exact nature and circuit location of the trouble.
d. Pinpoint the faulty component or part(or circuit board if spares are readily available) and replace it.

e. Prior to reapplying ac power, attempt to determine the reason the part of component failed. In many cases, the failure may be attributable to a non-specific fault such as abnormal component aging or non-recurring transients from related equipment. If possible, correct the cause of the failure. Initiate operation of the instrument, observing carefully for signs of impending failure.

f. Thoroughly test the instrument and its operation with related equipment. Perform any necessary adjustments (Paragraph 5.7) and return the instrument to normal operation.

5.7 LOGIC TROUBLESHOOTING

Troubleshooting procedures for transistor-transistor logic (TTL) and diode-transistor logic (DTL) are discussed in this section. The TTL family does not lend itself to troubleshooting very easily in that only one basic type of input may be used to examine circuit operations, in addition to normal inputs. The DTL family, however, lends itself to test signal injection and a great deal of testing can be done in the circuit with an oscilloscope and a few resistors.

5.7.1 TTL TROUBLESHOOTING

The most useful troubleshooting tool for TTL is ordinary examination of circuit behavior. Since TTL can respond to pulses narrower than 20 nanoseconds, it is important that an oscilloscope be used to examine cirucit operations. The oscilloscope must have a bandwidth of at least 50 MHz, preferably 100 MHz or more. A sampling-type oscilloscope is not suitable since the waveforms appearing may not be repetitive. Due to the high frequency characteristics of TTL,

care must be exercised not to change circuit operation by adding excessively long leads, etc., when making test connections. A second technique which can be used for TTL is to momentarily short-circuit an output ground. All TTL circuits examined are specified to withstand a short-circuit to ground in excess of 1 second provided only one output per chip is shorted to ground at a time. This rule of a one-second limit and one output per chip is a good rule to follow on any integrated circuit but was specifically derived for examination of the characteristics of the 7400 Series TTL logic circuits, as well as many other TTL families.

The 7400 Series is typical of a TTL logic family and the following voltages apply directly to the 7400 Series, but are an excellent guide for all TTL using 5-volts VCC.

Any voltage between +2.4 and +5 volts is considered a valid logic "one", while any voltage below 0.4 volts is considered a valid logic "zero". Typically, a logic "one" falls between +3 and +4 volts, while a logic "zero" falls between +0.2 and +0.3 volts.

5.7.2 DTL TROUBLESHOOTING

DTL is easier to troubleshoot since it has passive pull-up devices on the outputs of the various stages, which allow "loading" by resistors to ground and indefinite duration short-circuits to ground. DTL gates do exist with active pull-ups. For these gates, the one second, one output rule must be obeyed. Therefore, if it is unknown whether the output is active pull-up or passive pull-up for a given gate, it is best to obey the one second, one output rule. Flip-flops can also cause problems, since shorting the output of a flip-flop may cause it to change state or may feed back to the input through internal feedback paths and change the characteristics of the flip-flops

thus generating misleading results. The susceptibility of flip-flops to this kind of problem can only be determined by examination of the manufacturer's data sheet or other appropriate data reference sheet Any flip-flop which can be collector "OR'ed" may have its output short-circuited to ground without producing effects not shown by the logic diagram. Since it is often possible to do so, it is desirable to determine what the mode of failure is in order to determine which integrated circuits failed, so that only one need be removed from the circuit board. If wire-wrap or other replaceable integrated circuit techniques are used, these tests need not be performed in great detail since once a gate is even strongly suspected it may be easily checked by replacing it.

5.7.2.1 Input Diode Open. To check for an open input diode first note that the input appears normal. Adjust the other inputs to logic "high" and "low", watching the output of the gate. If the output does not vary, it is still possible that the output has failed. To check for output failure, adjust the inputs to give another input control and cause the other input to go from logic "one" to logic "zero" while observing the output. If the output still does not change, then the problem probably lies in the output area.

5.7.2.2 Input Diode Short-Circuit. To check for a short-circuited input diode, observe that the input voltage varies between approximately ground and +2 volts when being driven in the normal manner. This problem could still be caused by the driving output stage having a failure. To check for input diode short-circuits, connect a 6.8K resistor between VCC and the suspected input with the driving output in the "high" state. If this resistor pulls the line "high", that is, to very nearly +5 volts, then the driving output is defective. If the line remains at approximately 2 to 3 volts, the input diode is probably short-circuited.

5.7.2.3 Output Transistor Open. Adjust the inputs to cause the output transistors to pull down ("low"). If the output does not drop to the required logic "low" level, connect a 1K resistor from the output to ground. This should pull the output nearly to ground, at least down to 2 volts. If this occurs, the output transistor is open. If this does not occur, a condition may exist in which the output is being held high by force, such as a short to VCC.

5.7.2.4 Output Transistor Short-Circuited. Adjust the inputs for a high output. If the output is "low", attach a 6.8K resistor to VCC from the output. This should pull the output "high", that is, to nearly +5 volts. If the output remains low, check to be sure the output is not at absolute ground but is at least 100 millivolts off ground. If the output is 100 millivolts above ground, final confirmation can frequently be accomplished by isolating the output by complete removal of solder from the connection at the lead of the integrated circuit of concern. After solder removal, it is necessary to check continuity with a ohmmeter to ensure that the circuit is open.

If the output is at absolute ground, the probable cause is a short-circuit through solder or PC material directly to ground. If the output is 100 millivolts above ground, final confirmation can frequently be accomplished by isolating the output by complete removal of solder from the connection at the lead of the integrated circuit of concern. After solder removal, it is necessary to check continuity with an ohmmeter to ensure that the circuit is open.

5.7.2.5 Input to Output Short-Circuit. A common but often difficult to locate mode of failure is an input to output short-circuit on an inverting-type gate. This can be detected by noting that the input and output move together between ground and approximately 1.5 to 2 volts. This type of symptom can propagate through many levels of gating, so care must be exercised when troubleshooting for this type of failure.

5.7.3 DTL TROUBLESHOOTING HINTS

As always, it is important to check power supply and ground connections at the chip pins. This is doubly important if the chip only pulls down to approximately 1.5 volts and, for a logic "high", swings all the way up to VCC. Such a condition occurs when a ground connection is open on a given integrated circuit.

For DTL, the acceptable logic levels based on the 930 Series are 0 to +0.5 volts for a logic "low", and +2.5 to +5 volts for logic "high". Typical DTL levels are approximately 0.3 volts for a logic "low" and full VCC for a logic "high".

Certainly the quickest troubleshooting procedure is to examine the circuit for normal operation, observe what inputs are occurring on a gate, observe what output they generate, and noting whether this output is correct for the particular inputs.

When it is desirable to generate test inputs, a logic "low" may be generated by short-circuiting various logic levels to ground, obeying the one output, one second rule. Caution must be observed to avoid short-circuiting any logic line to +5 volts directly, as this may cause damage to the output stage connected to that line.

5.8 ADJUSTMENTS

Adjustments to the ratiometer are described in the following paragraphs. The adjustments have been performed at the factory prior to

shipment, and should be required only to compensate for normal component aging or parts replacement after repairs.

WARNING

THE FOLLOWING ADJUSTMENTS MUST BE MADE WITH THE COVER OF THE INSTRUMENT REMOVED, EXPOSING THE AC POWER AND THE +250 VOLT POWER TERMINALS TO MAINTENANCE PERSONNEL. HAZARDOUS VOLTAGE LEVELS MAY EXIST WITHIN THE INSTRUMENT EVEN WHILE THE FRONT PANEL POWER SWITCH IS PLACED IN THE OFF POSITION.

EXERCISE CAUTION NOT TO CONTACT ANY POINTS EXCEPT THE DESIGNATED TEST POINTS AND CONTROLS WHILE PERFORMING ANY ADJUSTMENTS.

CAUTION

Remove ac power from the instrument before attempting to remove or insert the printed circuit boards as damage to the components may result. Avoid dropping metallic objects into the circuitry. Exercise care in attaching test probes.

NOTE

Allow sufficient time for the instrument and all test equipment to reach operating temperatures before performing any adjustments to the instrument (at least ten minutes).

5.8.1 POWER SUPPLY ADJUSTMENTS

The ±15 volt and +5 volt power supplies are adjustable; the +250 volt power supply for the neon digital readout tubes is fixed and requires no adjustment. The individual power supply adjustments are described in the following paragraphs:

5.8.1.1 ±15 Volt Adjustment. The reference voltage for the + and -15V dc supplies are interconnected and only one adjustment is used to set both supplies. With the multimeter set to a dc voltage range greater than 20 volts, place the negative (-) probe on TS1-1 and the positive (+) probe on TS1-4 of the power supply. Turn the power on. Adjust power supply circuit board (A10A1) potentiometer R7 to provide a +15 volt indication on the meter. Move the positive test probe to ground (TS1-1) and the negative test probe to TS1-3. The negative supply should indicate -15V ± 5%.

5.8.1.2 +5 Volt Adjustment. To adjust the +5 volt supply, monitor the voltage between TS1-1 (gnd) and TS1-2 (+5) with a dc voltmeter. Adjust R2 on the 5 volt regulator board (A10A2) to +5V ± 5%.

5.8.2 ANALOG SUBSYSTEM ALIGNMENT PROCEDURE

The adjustments described in the following paragraphs will assure proper and accurate operation of the analog portion of the display unit. Since the analog sections of Channel A are identical to those of Channel B; only the ones in Channel A will be discussed.

5.8.2.1 AC to DC Converter Alignment. The front panel controls of the ratiometer (Channel A) should be set as follows:

Control	Position
DISPLAY RANGE Switch	100%
TRIGGER Switch	INT
PERIOD-SECONDS Switch	.1
*BOLO/XTAL Switch	XTAL
*ATTENUATION, dB Switch	60
GAIN Control	Minimum (fully CCW)
GAIN SELECT Switch	VAR
POWER Switch	OFF
MODE Switch	A

a. Arrange conveniently and interconnect the test equipment shown in Figure 5-1 to Channel A input. Ensure that all test equipment ground connections are isolated from ac power ground by using an ungrounded ac plug adapter (grounded, 3-prong male to ungrounded, 2-prong female, such as Hubbell #5273-L).

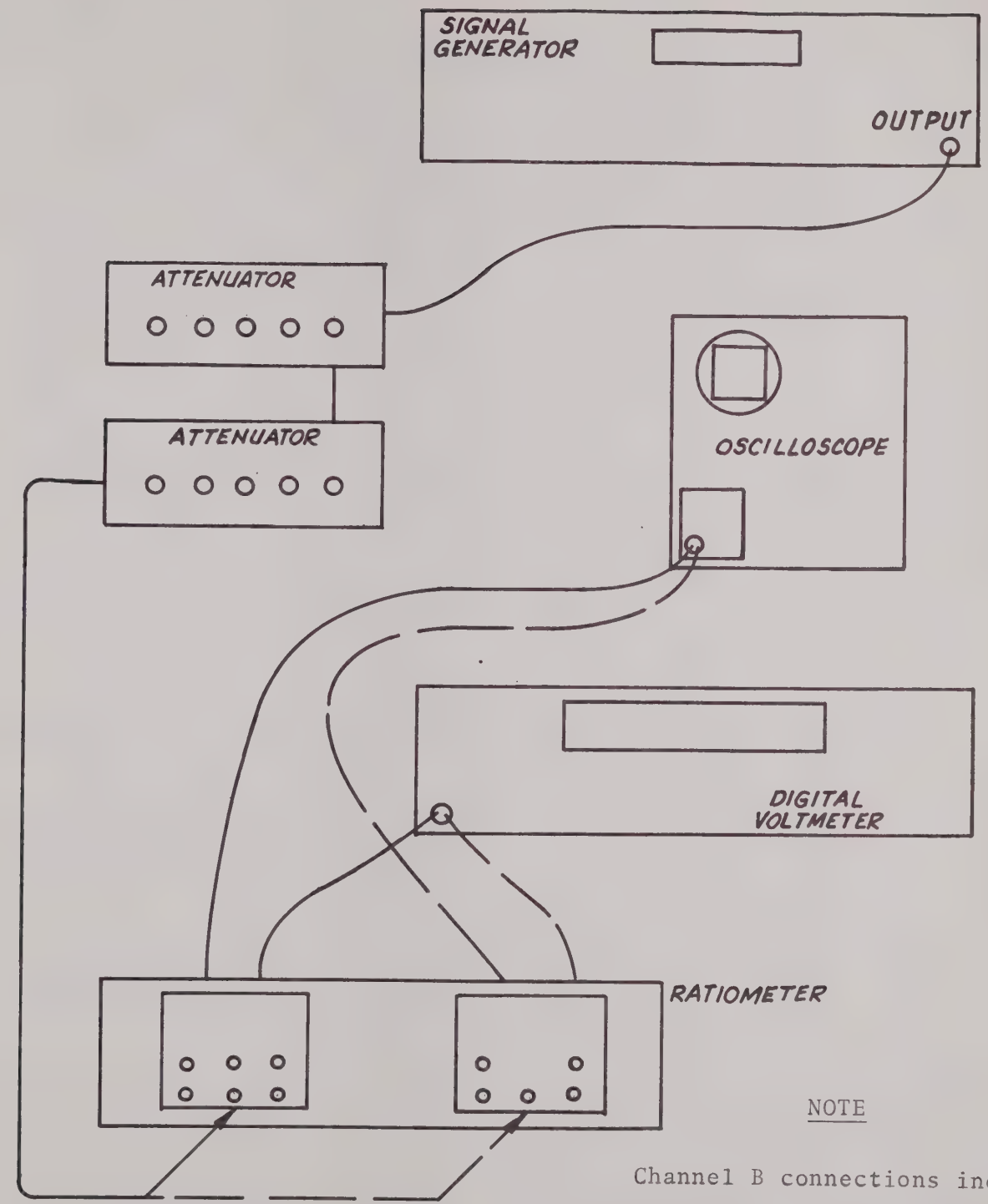
b. Set the test oscillator controls as follows:

Control	Position
Frequency - Range	X1K
- Vernier	1
Output Attenuator	+20 (3.0 volts)
Amplitude - Coarse	Approximately 1 volt
- Fine	1.00 volt

c. Adjust the calibrated external attenuator for 10 dBV attenuation.

d. Apply ac power to the instruments and allow several minutes for the equipment to reach normal operating temperatures. Adjust the signal generator frequency vernier for maximum display unit indication.

*Preamplifier models only.



41E034Z

Figure 5-1. Test Equipment Set-Up

e. Using an ac plug adapter (Hubbell #5273-L or equivalent), isolate the oscilloscope from ac power ground. Connect the oscilloscope input probe to the reference limiter unit (A1A3) TP1. Adjust A1A3R16 for a peak 1 kHz output (approximately 10V p-p).

f. Move the oscilloscope input probe to the synchronous demodulator (A1A2) test point TP2. Connect the oscilloscope probe ground clip to a convenient chassis ground. Adjust the oscilloscope horizontal display for two or three display cycles.

g. Adjust the synchronous demodulator (A1A2) symmetry adjustment R22 for maximum positive peak indication on the oscilloscope.

h. Adjust the synchronous demodulator (A1A2) phase adjustment R6 for maximum positive peak indication on the oscilloscope.

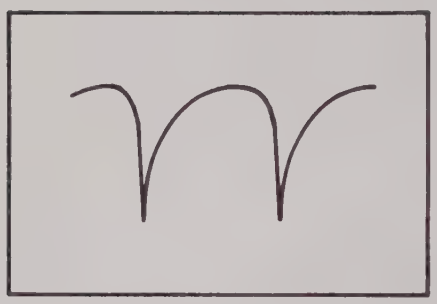
i. Readjust A1A2R22, then A1A2R6, as required until maximum positive peak level is displayed on the oscilloscope.

j. Readjust the oscilloscope horizontal controls, as required, such that two negative signal peaks are displayed with no multiple trace triggering. Set the oscilloscope vertical sensitivity to 1 volt per division.

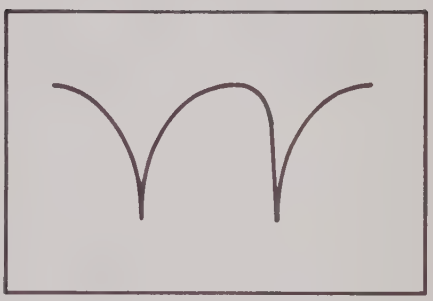
k. The phase and symmetry adjustments (A1A2R6 and A1A2R22) must be adjusted for symmetry of the displayed waveform. Adjust A1A2R6 or A1A2R22 as indicated in Figure 5-2.

The ac to dc conversion alignment is now completed. Continue with the scale alignment procedure.

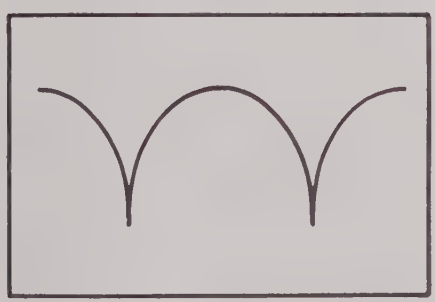
5.8.2.2 Lin/Log Amplifier (Scale) Alignment. The ratiometer unit is a precision instrument; hence, to obtain a maximum performance and greatest accuracy, scale alignment should be carefully performed by qualified technicians.



R6 IMPROPERLY
ADJUSTED



R22 IMPROPERLY
ADJUSTED



R6 AND R22
PROPERLY ADJUSTED

Figure 5-2. Idealized Adjustment Waveforms

Since great care and highly accurate maintenance equipment is required for this alignment, consultation with your nearest Scientific-Atlanta sales representative is recommended for information and assistance.

Before continuing with the following procedure, carefully read the notice below.

NOTE

All subassemblies of the instrument must be adjusted in accordance with the preceding portions of Paragraph 5.8 prior to performance of the lin/log amplifier (scale) alignment.

The alignment technician should become familiar with the test equipment prior to performance of the following procedure.

a. Assemble and interconnect the signal generator through the attenuator to the input of Channel A. Ensure that the test equipment is isolated from ac power ground as described in Paragraph 5.8.2.1, step a. Change the unit front panel control settings to the following positions:

Control	Setting
DISPLAY RANGE Switch	80 dB
TRIGGER Switch	INT
PERIOD-SECONDS Switch	.1
GAIN SELECT Switch	VAR
*BOLO/XTAL Switch	XTAL
*ATTENUATION, dB Switch	40 dB
POWER Switch	ON
GAIN Control	Minimum (fully CCW)
MODE Switch	A

*Preamplifier models only

b. Allow several minutes for the equipment to reach operating temperature. Set the calibrated attenuator to -20 dBV such that a 100 millivolt level is presented to the display unit. With the oscilloscope probe connected to synchronous demodulator (A1A2) test point TP2, and the ground clip attached to chassis ground, adjust the front panel GAIN potentiometer for a 3.9 ±0.1 volt (peak-to-peak) level on the oscilloscope.

Steps c, d, e, f, and g describe the linear (100%) scale adjustment.

c. Connect the digital voltmeter between test point TP4 and ground on the lin/log amplifier, A1A4.

d. Place the DISPLAY RANGE switch in the 100% position. Disconnect the input at the front panel INPUT connector.

e. Adjust the lin zero potentiometer A1A4R15 for 0V ±1 mV dc at lin/log amplifier test point TP4.

f. Reconnect the input signal to the INPUT connector.

g. Adjust lin/log amplifier (A1A4) potentiometer R21 to provide a dc level of 10V ±10 mV at A1A4TP4.

Steps h, i, j, and k below, comprise the logarithmic scale zero adjustment.

h. Place the DISPLAY RANGE switch in the 80 dB position.

i. Connect the digital voltmeter between test point TP1 and ground on the lin/log amplifier (A1A4).

j. Adjust R6 on the lin/log amplifier (A1A4) to produce 0V ±1 mV dc at A1A4TP1.

k. Move the voltmeter probe to A1A4TP2. Adjust A1A4R12 to produce 0V ±1 mV dc at A1A4TP2.

Steps l, m, n, and o below, comprise the log amplifier gain adjustment.

l. Increase the attenuation of the calibrated external attenuator by 40 dB such that an input level of -60 dBV (1 mV rms) is presented to the display unit INPUT connector.

m. With the voltmeter probe connected to A1A4TP2, adjust lin/log amplifier (A1A4) potentiometer R8 to produce 2.000V ±1 mV dc at A1A4TP2.

n. Increase the external attenuation another 40 dB such that an input level of -100 dB (10μV rms) is presented to the display unit.

o. Adjust the front panel LOG CONFORMITY control with a small screwdriver to produce 4.000V ±1 mV dc at A1A4TP2.

Steps p, q, r, s, and t below, comprise the 80 dB scale adjustment.

p. Decrease the attenuation of the calibrated external attenuator by 80 dB such that an input level of -20 dBV (0.1V rms) is presented to the display input connector. The voltage at A1A4TP4 should be 0V ±1 mV dc.

q. Increase the attenuation of the calibrated external attenuator by 40 dB such that an input level of -60 dBV (1 mV rms) is presented to the display unit INPUT connector.

r. With the voltmeter probe connected to A1A4TP4, adjust lin/log amplifier (A1A4) potentiometer R25 to produce 4V ±1 mV dc at A1A4TP4.

s. Increase the external attenuation another 40 dB such that an input level of -100 dBV (10μV rms) is presented to the display unit.

t. Adjust the front panel LOG CONFORMITY control with a small screwdriver to produce 8V ±2 mV dc at A1A4TP4.

Steps u, v, and w comprise the 20 dB scale adjustment.

u. Reduce the external attenuation by 60 dB, returning the level presented to the INPUT connector to -40 dBV (10 mV rms).

v. Reposition the front panel DISPLAY RANGE switch to the 20 dB position.

w. Adjust lin/log amplifier (A1A4) potentiometer R23 to produce a dc level of 10V ±10 mv dc at A1A4TP4.

5.8.2.3 Difference Alignment. The same alignment procedure described in Paragraph 5.8.2.1 and 5.8.2.2 should be carried out on both Channels (A & B) before proceeding to the difference unit A9. Once both channels are aligned interconnect the test equipment as shown in Figure 5-3 leaving the oscillator controls set as in Paragraph 5.8.2.1b.

a. Adjust each calibrated external attenuator for 10 dB attenuation.

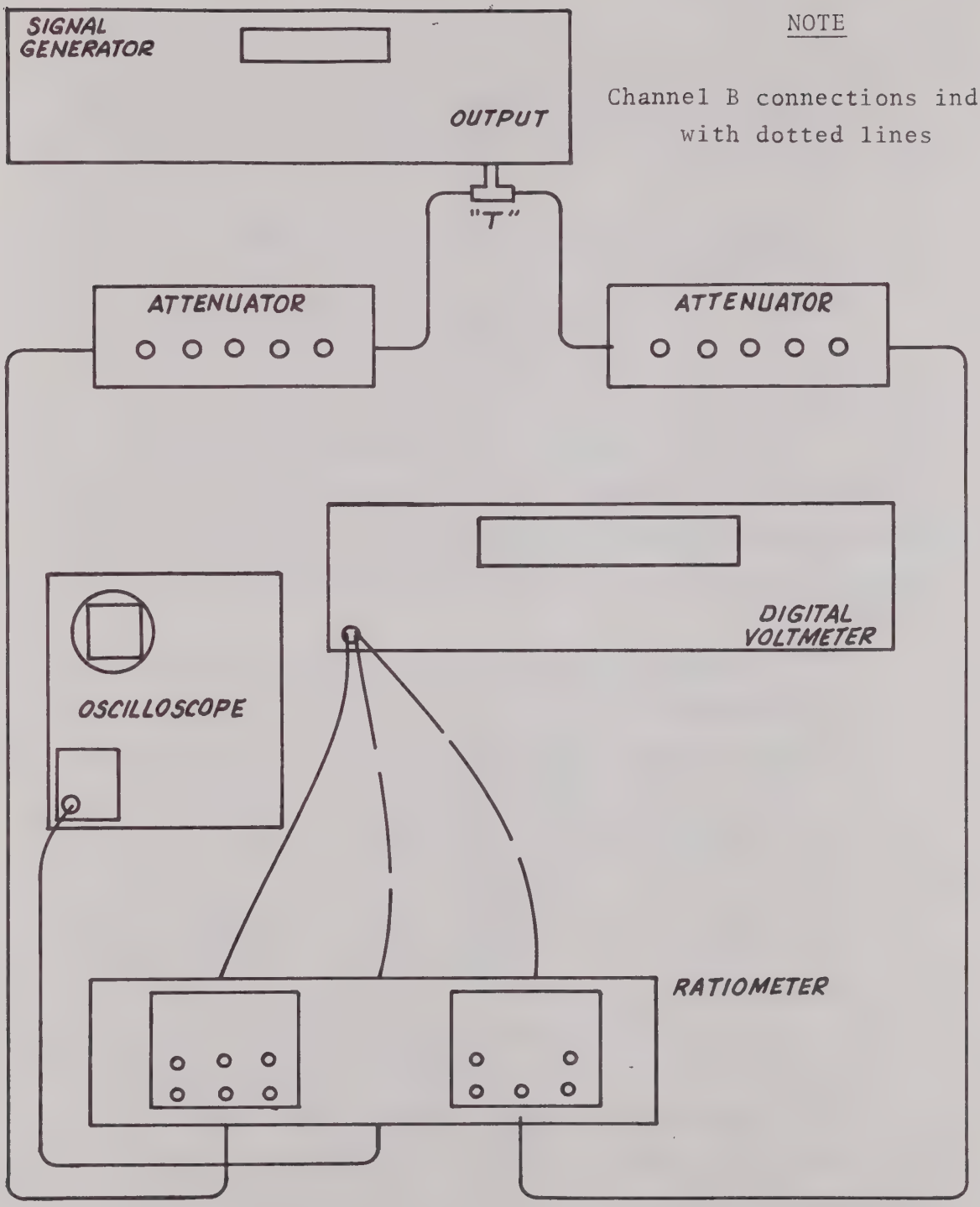
b. With the front panel MODE switch to A/B, adjust the GAIN control of each channel until 0V ±1 mV dc is observed on the digital voltmeter connected at A1A4TP2 for Channel A and A11A4TP2 for Channel B.

c. Move the digital voltmeter probe to A1A4TP4 and adjust the GAIN control on Channel B until the voltmeter reads 0V ±1 mV dc.

d. Increase the external attenuator attenuation in Channel A by 40 dB, and adjust A9R32 on the difference unit until the digital voltmeter reads 4V ±1 mV dc.

Steps e through k comprise the out-of-range adjustment for the difference unit.

e. Return the external attenuator in Channel A to 20 dB attenuation.



NOTE

Channel B connections indicat
with dotted lines

Figure 5-3. Test Equipment Set-Up

f. Adjust the GAIN control in Channel B until the digital voltmeter reads +1.1V ±10 mV dc at A1A4TP4.

g. With oscilloscope connected to XA9 pin A adjust A9R12 until a logic level transistion from a low to a high level (0V to 5V) is observed.

h. With the oscilloscope still connected to XA9 pin A and digital voltmeter to A1A4TP4, adjust the GAIN control in Channel B until the digital voltmeter reads 1V ±1 mV dc.

i. Set the attenuator in Channel A to 10 dB and the attenuator in Channel B to 20 dB.

j. Adjust the GAIN control in Channel A until 1.1V ±10 mV dc is observed on digital voltmeter.

k. Adjust A9R3 until a logic level transistion from a low

Steps 1 through p comprise the sum adjustment for the difference unit.

l. Repeat step a.

m. With the front panel MODE switch to A·B, adjust the GAIN control of each channel until 0V ±1 mV dc is observed on the Digital Voltmeter connected at A1A4TP2 for Channel A and A11A4TP2 for Channel B.

n. Move the Digital Voltmeter probe to A9TP3 and monitor the voltage. It should read 0.00V dc.

o. Move the Digital Voltmeter probe to A4TP3 and adjust R53 for 0.00V dc.

p. Attenuate the Channels A and B input signals by 10 dB each and adjust R54 for a 20.0 dB reading on the digital display.

5.8.2.4 Input Amplifier A4 (A14) Adjustment. With a 2.0V (rms) input signal applied to either the front or rear panel input connector, the GAIN selector switch to FIXED, and the DISPLAY range switch to 80 dB, adjust A4R1 (A14R1) for a 00.0 dB repeating display.

The above procedures, if carefully performed, provide the alignment required for proper scale adjustments and alignment of the analog portion of the unit, except input amplifier optional preamplifier input adjustments, which are given below.

5.8.2.5 Optional Active Filter/Bolometer Current Supply A1A1 (A11A1) Adjustments.

Active Filter:

With the desired input signal connected (normally 1000 Hz for 60 Hz operation, 1025 Hz for 50 Hz operation), adjust the input signal level and/or preamplifier gain for 4V (peak-to-peak) as observed on an oscilloscope connected between TP3 and ground

(Figure 7-2). Next, adjust R5 for maximum signal level as observed on the oscilloscope. Readjust the input for 4V (peak-to-peak), if required, and check the bandwidth of the filter (which should be 30-Hz ±5-Hz) by varying the frequency of the input signal above and below until the output at TP3 is decreased by 3 dB (0.707) of oscilloscope reading.

If the bandwidth is greater than 35 Hz, adjust R19 approximately one turn in the CW direction and recheck the bandwidth. If the bandwidth is less than 25 Hz, adjust R19 approximately one turn in the CCW direction and recheck the bandwidth.

Bolometer Current:

To adjust the current to the bolometer, the BOLO-XTAL switch on the preamplifier must be in the BOLO position and the bolometer to be used connected to the input jack. By connecting a 20,000 ohm/volt voltmeter (Simpson 260 or equivalent) between TP4 (+) and TP5 with the meter scale set to the 2.5 - volt dc range, adjust R12 for the desired current.

NOTE

The voltmeter reading is made across a 100 ohm resistor in series with the bolometer output current. The voltmeter will indicate 1 volt for each 10 milliamperes.

5.8.3 DIGITAL SUBSYSTEM ALIGNMENT

Two digital subsystem modules require adjustment in the Model 1833A-10 Ratiometer. These are: the oscillator on the interconnect and 6.4 MHz oscillator subassembly (A1A5) requires tuning, and the dual-slope integrator module (A1A5A2) requires adjustment to minimize deviation of the indicated level from the true input level (tracking error) over the indicated display ranges. These subassemblies in Channel B (A11A5 and A11A5A2) require adjustment in the Model 1833A-20 Ratiometer.

5.8.3.1 Interconnect and 6.4 MHz Oscillator (A1A5 or A11A5) Adjustment.

a. Assemble and interconnect the test setup shown in Figure 5-1. Ensure that the equipment grounding precautions described in Paragraph 5.8.2.1 are observed.

   Pin 4 of A1A5U1 is the oscillator output, so the oscilloscope probe may be connected directly to this point.

   Connect the oscilloscope probe ground clip to the chassis or any convenient ground point.

b. Adjust the tunable inductor (A1A5L1) for 6.4 MHz (156 ns). The minimum acceptable output level at this point is 3 volts peak-to-peak.

CAUTION

Do not force the stops on the inductor. Physical damage may result.

This completes the tuning of the oscillator.

5.8.3.2 Dual-Slope Integrator Adjustment Procedure.

NOTE

Prior to performing the following adjustments, the analog subsystem must be properly aligned (Paragraph 5.8.2).

a. Set the display unit front panel controls as follows:

Control	Position
DISPLAY RANGE Switch	20 dB
TRIGGER-INT/EXT Switch	INT
PERIOD-SECONDS Switch	.1
*BOLO/XTAL Switch	XTAL
*ATTENUATION, dB Switch	60
GAIN Control	Minimum (fully CCW)
POWER-ON/OFF Switch	OFF
MODE Switch	A

b. Internally, adjust dual-slope integrator (A1A5A2) potentiometers R9, R11, and R42 to mid-range.

*Preamplifier Models only

c. After warm-up, adjust the front panel GAIN and ATTENUATION controls to obtain a repetitive display indication of approximately -19.90 dB on the lin/log display.

Indication: _____

Reposition the PERIOD-SECONDS switch to 1.0. Wait a few moments and note the repeating display indication.

Indication: _____

d. Reposition the PERIOD-SECONDS switch to .01 and adjust dual-slope integrator potentiometer R42 to obtain a repetitive display the same as indication #2 (above).

e. Repeat steps c and d until the same display indication appears repeatedly in all three PERIOD switch positions.

f. Connect the digital voltmeter to A1A4TP4. Reposition the PERIOD-SECONDS switch to .1. Adjust the Channel A GAIN and ATTENUATION controls to obtain 0.0 ±2 mV dc as measured with the digital voltmeter (DVM).

g. Adjust dual-slope integrator potentiometer R9 for a repetitive lin/log display indication of 0.00 dB.

h. Readjust the front panel GAIN and ATTENUATION controls for +9.990V ±2 mv dc measured at A1A4TP4 with the DVM.

i. Adjust R11 on the dual-slope integrator for a repetitive display indication of -19.98 dB.

j. Repeat steps f, g, h, and i until the 0.0 ±2 mV and +9.990 ±2 mV dc voltages at A1A4TP4 correspond with repetitive display indications of 0.00 dB and -19.98 dB (respectively).

k. For the dual channel display Model 1833A-20 Ratiometer, repeat the above measurements for Channel B on dual-slope integrator A11A5A2 with the DVM at A11A4TP4.

This completes alignment of the digital subsystem.

CHAPTER 6
PARTS LISTS

6.1 GENERAL

The parts lists for standard Series 1833A Logarithmic Ratiometers and standard options are included in this chapter. Special modifications, if any, are described at the front of this manual.

6.2 EXPLANATION OF COLUMN HEADINGS

COMP DESIG

This column contains the assigned reference designation. The reference designation appears on the referenced figure.

S-A PART NO

The Scientific-Atlanta part number is listed in this column.

DESCRIPTION

A brief electrical and/or mechanical description of the component is contained in this column. Abbreviations used are given at the end of this chapter.

FSCM

The manufacturer's Federal Supply Code for Manufacturers codes are entered here. The code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) effective on the publication date of this manual. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks. Identifying codes are cross-referenced (Code to Name) at the end of this chapter.

Mfr. Part No.

The number assigned to the part by the manufacturer is listed in this column.

6.3 ORDERING PARTS

When ordering parts from Scientific-Atlanta, always include the Scientific-Atlanta part number, the part description, the unit serial number, unit name, subassembly name, part manufacturer, and manufacturer's part number.

6.4 OPTIONAL MODULE REFERENCE DESIGNATION CHART

In each of the two models in the Series 1833A Logarithmic Ratiometers, four options are available. Optional modules are supplied or not supplied, depending on the model number and option suffixes. Be sure to include the complete model number in any correspondence regarding ratiometers. The table below lists the models and S-A part numbers of optional modules that may be supplied with them.

OPTION / COMP. DESIG.	STD	OPT-1	STD	OPT-2	STD	OPT-3	STD	OPT-4
CASE	--	--	--	--		113136	--	--
A1A1	--	--	--	115059	--	--	--	--
A3	--	113718	--	--	--	--	--	115570
A4	115546	115546	115546	115505	115546	115546	115546	115546
A4A1	--	--	--	--	--	--	--	--
A11A1	--	--	--	115059	--	--	--	-
A13	--	113718 [2]	-	--	-	--	--	115570 [2]
A14	115545 [1]	115545 [1]	115545 [1]	115547 [3]	115545 [1]	115545 [1]	115545 [1]	115545 [1]
A14A1	--	--	--	46874	--	--	-	-

1. P/N 11545 on Model 1833A-10
2. Omitted on 1833A-10 model
3. P/N 115547 on Model 1833A-10

PARTS LIST ASSY LOGARITHMIC RATIOMETER MODEL 1833, INCL OPTIONS

1833 DRAWING NO 7-1 REF DESIG PREFIX —

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
A01	113723	MOTHER BOARD,CHANNEL A ASSY		
A02	113180	DIGITAL DISPLAY ASSEMBLY		
A03*	115570	BCD BYTE OUTPUT ASSY		
A03*	113718	BCD OUTPUT ASSEMBLY		
A04	115546	INPUT AMPLIFIER/DISPLAY ASSEMBLY		
A04*	115505	PREAMPLIFIER/DISPLAY ASSEMBLY		
A05		NOT ASSIGNED		
A06		NOT ASSIGNED		
A07		NOT ASSIGNED		
A08		NOT ASSIGNED		
A09	113673	DIFFERENCE ASSEMBLY		
A10	115068	POWER SUPPLY ASSEMBLY		
A11	113727	MOTHER BOARD CHANNEL B ASSY		
A12	113180	DIGITAL DISPLAY ASSEMBLY		
A13	115570	BCD BYTE OUTPUT ASSY		
A13	113718	BCD OUTPUT ASSEMBLY		
A14	115545	INPUT AMPLIFIER ASSEMBLY		
A14*	115547	PREAMPLIFIER ASSEMBLY		
J01	80987	CONN COAX BNC FEM TO CUP SHELL ISOLATED		4890-7 NT-34 PLATING
J02	76460	CONN COAX BNC FEM TO .110 CBL CRIMP D-HL	02660	31-318
J03	71063	CONN COAX BNC FEM TO CUP DBL D HOLE MT		UG-657/U
J04	71063	CONN COAX BNC FEM TO CUP DBL D HOLE MT		UG-657/U
J05	77020	CONN RND 10-COND FEM CHASSIS MT LCK RING	81312	M10SLRN
J06*	79634	CONN RECT 50-COND FEM CHASSIS MT W/LOCK	02660	57-40500
J07	80987	CONN COAX BNC FEM TO CUP SHELL ISOLATED		4890-7 NT-34 PLATING
J08	76460	CONN COAX BNC FEM TO .110 CBL CRIMP D-HL	02660	31-318
J09	71063	CONN COAX BNC FEM TO CUP DBL D HOLE MT		UG-657/U
J10	71063	CONN COAX BNC FEM TO CUP DBL D HOLE MT		UG-657/U
J11*	77020	CONN RND 10-COND FEM CHASSIS MT LCK RING	81312	M10SLRN
J12*	79634	CONN RECT 50-COND FEM CHASSIS MT W/LOCK	02660	57-40500
J13	71063	CONN COAX BNC FEM TO CUP DBL D HOLE MT		UG-657/U
P01	77589	CONN COAX 27 THREADED FEM RT ANG .12 CBL	02660	27-26
P02	77589	CONN COAX 27 THREADED FEM RT ANG .12 CBL	02660	27-26
S01	77278	SWITCH ROT 2P 2-5 POS NSH 36 DEG 1/8 SHF	95146	MRA2-5S
S02	79635	SWITCH ROT 4P 5 POS NSH 2 SEC	71590	PS111

*SEE PARAGRAPH 6.4

PARTS LIST ASSY LOGARITHMIC RATIOMETER MODEL 1833, INCL OPTIONS

1833 DRAWING NO 7-1 REF DESIG PREFIX

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
S03	72895	SWITCH BUTTON SPDT BREAK MAKE BLACK	82389	913BU
1*	113136	CASE,SER 17		

*SEE PARAGRAPH 6.4

MOTHER BOARD

REF DESIG PREFIX A1

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
C01	70671	CAPACITR 100 MF 25V	80183	500D107G025DD7
C02	70671	CAPACITR 100 MF 25V	80183	500D107G025DD7
C03	70481	CAPACITR 20 PF 500V MOLDED SILV MICA 5%	14655	22R5Q2
J01	76973	CONN COAX 27 THREADED MALE TO LUG CHS MT	02660	27-9
J02	81541	SOCKET DUAL IN LINE 16 PIN	91506	316-AG5D-R
J03	76973	CONN COAX 27 THREADED MALE TO LUG CHS MT	02660	27-9
R01	72014	RESISTOR 6.8K OHM 1/4W 10% COMP	01121	RCR07G682KS
R02	71938	RESISTOR 680 OHM 1/4W 10% COMP	01121	RCR07G621KS
R03	79452	RESISTOR 1.0K OHM .1W .01%	91637	MWA-8
R04	71907	RESISTOR 220 OHM 1/4W 10% COMP	01121	RCR07G221KS
R05	71907	RESISTOR 220 OHM 1/4W 10% COMP	01121	RCR07G221KS
R06	75651	RESISTOR 2.0K OHM 1/4W 5% COMP	01121	RCR07G202JS
R07	75651	RESISTOR 2.0K OHM 1/4W 5% COMP	01121	RCR07G202JS
R08	74727	RESISTOR 10K OHM 1/4W 5% COMP	01121	RCR07G103JS
U01	77581	IC OP AMP GEN.PUR. TO-5 UNCOMP.+70C 709C	80211	MC1709CG
XA01	76587	CONNECTR 15 PIN DOUBLE READOUT	71785	252-15-30-160
XA02	76587	CONNECTR 15 PIN DOUBLE READOUT	71785	252-15-30-160
XA03	76587	CONNECTR 15 PIN DOUBLE READOUT	71785	252-15-30-160
XA04	76587	CONNECTR 15 PIN DOUBLE READOUT	71785	252-15-30-160
XA05	78279	CONNECTR 22 PIN DOUBLE READOUT	71785	252-22-30-160

PARTS LIST ASSY FILTER/BOLOMETER CURRENT, INCL W/OPTION-2*

1833 DRAWING NO 7-2 REF DESIG PREFIX A1A1, A11A1

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
CR01	71142	DIODE 1N4154 SIL 25V 150MA	80368	1N4154
CR02	71142	DIODE 1N4154 SIL 25V 150MA	80368	1N4154
C01	73498	CAPACITR 820 PF 500V SILVER MICA 5%	14655	CD19FD821J03
C02	70671	CAPACITR 100 MF 25V		5C0D107G025DD7
C03	80139	CAPACITR .1 MF 50V CER SQUARE	72982	8131-M05C-651-104Z
C04	70671	CAPACITR 100 MF 25V		5C0D107G025DD7
C05	80139	CAPACITR .1 MF 50V CER SQUARE	72982	8131-M05C-651-104Z
C06	76696	CAPACITR .01 MF 500V SILVER MICA 5%	14655	CD30FD103J03
C07	76696	CAPACITR .01 MF 500V SILVER MICA 5%	14655	CD30FD103J03
C08	73893	CAPACITR .02 MF 300V SILVER MICA 5%	14655	CD30FD203J03
C09	70557	CAPACITR .0047 MF 100V MYLAR 10%	14655	WMF1D47
C10	73497	CAPACITR 180 PF 500V SILVER MICA 5%	14655	CD15FD181J03
C11	73506	CAPACITR .068 MF 100V MYLAR 10%	14655	WMF1S68
C12	70671	CAPACITR 100 MF 25V		5C0D107G025DD7
C13	70651	CAPACITR 25 MF 25V		5C0D256G025CB7
Q01	77148	TRANSSTR 2N3251 PNP SIL	80211	2N3251
R01	79716	RESISTOR 169K OHM 1/8W 1% MTL FLM		RN60C1693F
R02	71887	RESISTOR 100 OHM 1/4W 10% COMP		CB1011
R03	71887	RESISTOR 100 OHM 1/4W 10% COMP		CB1011
R04	80723	RESISTOR 3.01K OHM 1/4W 1% MTL FLM		RN60D3011F
R05	76980	POT 5K OHM 1W WW 20T PC MT	80294	3C05P-1-502
R06	78855	RESISTOR 105 OHM 1/4W 1% MTL FLM		RN60D105CF
R07	81405	RESISTOR 16.9K OHM 1/10W 1% MTL FLM		RN55C1692F
R08	81405	RESISTOR 16.9K OHM 1/10W 1% MTL FLM		RN55C1692F
R09	71966	RESISTOR 1.5K OHM 1/4W 10% COMP		GB1521
R10	71862	RESISTOR 47 OHM 1/4W 10% COMP		CB4701
R11	71927	RESISTOR 470 OHM 1/2W 10% COMP		EB4711
R12	76599	POT 500 OHM 1W WW 20T PC MT	80294	3C05P-1-501
R13	72002	RESISTOR 4.7K OHM 1/4W 10% COMP		GB4721
R14	71977	RESISTOR 2.2K OHM 1/4W 10% COMP		GB2221
R15	72019	RESISTOR 8.2K OHM 1/4W 10% COMP		GB8221
R16	71873	RESISTOR 56 OHM 1/4W 10% COMP		CB5601
R17	71887	RESISTOR 100 OHM 1/4W 10% COMP		CB1011

*SEE PARAGRAPH 6-4

PARTS LIST ASSY FILTER/BOLOMETER CURRENT, INCL W/OPTION-2*

1833 DRAWING NO 7-2 REF DESIG PREFIX A1A1, A11A1

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
R18	71829	RESISTOR 5 OHM 3W	24681	VAL3
R19	76595	POT 1K OHM 1W WW PC MT 20T	80294	3005P-1-102
U01	77581	IC OP AMPL 709C EQ	13715	U5B770939X

*SEE PARAGRAPH 6.4

PARTS LIST ASSY SYNCHRONOUS DEMODULATOR

1833 DRAWING NO 7-3 REF DESIG PREFIX A1A2, A11A2

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
CR01	71142	DIODE 1N4154 SIL 25V 150MA	80368	1N4154
CR02	71142	DIODE 1N4154 SIL 25V 150MA	80368	1N4154
CR03	71142	DIODE 1N4154 SIL 25V 150MA	80368	1N4154
CR04	71142	DIODE 1N4154 SIL 25V 150MA	80368	1N4154
C01	75217	CAPACITR 10 MF 50V		5C0D106G050CB7
C02	73505	CAPACITR .033 MF 100V MYLAR 10%	14655	WMF1S33
C03	70589	CAPACITR .1 MF 50V CER DISC	71590	CK104
C04	70629	CAPACITR 6.8 MF 35V SOLID TANT POL 10%	80183	1E4D-685X9035B2
C05	70629	CAPACITR 6.8 MF 35V SOLID TANT POL 10%	80183	1E4D-685X9035B2
C06	75417	CAPACITR .01 MF 150V CER DISC	71590	DDM-103
C07	70470	CAPACITR 10 PF 500V SILVER MICA 5%	14655	CD15CD100J03
C08	70470	CAPACITR 10 PF 500V SILVER MICA 5%	14655	CD15CD100J03
C09	70671	CAPACITR 100 MF 25V		5C0D107G025DD7
C10	70671	CAPACITR 100 MF 25V		5C0D107G025DD7
C11	70487	CAPACITR 27 PF 500V SILVER MICA 5%	14655	CD15ED270J03
C12	75217	CAPACITR 10 MF 50V		5C0D106G050CB7
C13	70618	CAPACITR 2 MF 200V MET MYLAR, OVAL	84411	X663F
C14	70671	CAPACITR 100 MF 25V		5C0D107G025DD7
C15	70671	CAPACITR 100 MF 25V		5C0D107G025DD7
Q01	78215	TRANSSTR 2N5089 PNP SIL	80211	2N5089
Q02	78215	TRANSSTR 2N5089 PNP SIL	80211	2N5089
Q03	78214	TRANSSTR 2N5087 PNP SIL	80211	2N5087
Q04	76446	TRANSSTR 2N4222 FET N-CHNL JUNC	80211	2N4222
Q05	76446	TRANSSTR 2N4222 FET N-CHNL JUNC	80211	2N4222
Q06	77148	TRANSSTR 2N3251 PNP SIL	80211	2N3251
R01	71897	RESISTOR 150 OHM 1/4W 10% COMP		GB1511
R02	72054	RESISTOR 22K OHM 1/4W 10% COMP		GB2231
R03	72026	RESISTOR 10K OHM 1/4W 10% COMP		GB1031
R04	71897	RESISTOR 150 OHM 1/4W 10% COMP		GB1511
R05	71951	RESISTOR 1.0K OHM 1/4W 10% COMP		GB1021
R06	76596	POT 10K OHM 1W WW 20T PC MT	80294	3006P-1-103
R07	71951	RESISTOR 1.0K OHM 1/4W 10% COMP		GB1021
R08	72153	RESISTOR 330K OHM 1/4W 10% COMP		GB3341
R09	72054	RESISTOR 22K OHM 1/4W 10% COMP		GB2231

PARTS LIST ASSY SYNCHRONOUS DEMODULATOR

1833 DRAWING NO 7-3 REF DESIG PREFIX A1A2, A11A2

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
R10	72039	RESISTOR 15K OHM 1/4W 10% COMP		GB1531
R11	72039	RESISTOR 15K OHM 1/4W 10% COMP		GB1531
R12	71951	RESISTOR 1.0K OHM 1/4W 10% COMP		GB1021
R13	71907	RESISTOR 220 OHM 1/4W 10% COMP		GB2211
R14	71907	RESISTOR 220 OHM 1/4W 10% COMP		GB2211
R15	72026	RESISTOR 10K OHM 1/4W 10% COMP		GB1031
R16	72077	RESISTOR 47K OHM 1/4W 10% COMP		GB4731
R17	78246	RESISTOR 10.0K OHM 1/4W 1% MTL FLM		RN60D1002F
R18	78246	RESISTOR 10.0K OHM 1/4W 1% MTL FLM		RN60D1002F
R19	78246	RESISTOR 10.0K OHM 1/4W 1% MTL FLM		RN60D1002F
R20	78577	RESISTOR 20.0K OHM 1/4W 1% MTL FLM		RN60D2002F
R21	78248	RESISTOR 1.00K OHM 1/4W 1% MTL FLM		RN60D1001F
R22	76595	POT 1K OHM 1W WW PC MT 20T	80294	3006P-1-102
R23	78248	RESISTOR 1.00K OHM 1/4W 1% MTL FLM		RN60D1001F
R24	78577	RESISTOR 20.0K OHM 1/4W 1% MTL FLM		RN60D2002F
R25	78907	RESISTOR 5.90K OHM 1/4W 1% MTL FLM		RN60D5901F
TP01	76920	JACK TEST BROWN	74970	105-758
TP02	71363	JACK, TEST, P.C., RED	74970	105-752
T01	78450	XFMR PRI 10KCT 2MADC SEC 10KCT	00348	MMT29-FB
U01	77581	IC OP AMPL 709C EQ	13715	U5B770939X

PARTS LIST ASSY REFERENCE LIMITER CIRCUIT

1833 DRAWING NO 7-4 REF DESIG PREFIX A1A3, A11A3

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
CR01	71142	DIODE 1N4154 SIL 25V 150MA	80368	1N4154
CR02	71142	DIODE 1N4154 SIL 25V 150MA	80368	1N4154
CR03	71142	DIODE 1N4154 SIL 25V 150MA	80368	1N4154
CR04	71142	DIODE 1N4154 SIL 25V 150MA	80368	1N4154
C01	73506	CAPACITR .068 MF 100V MYLAR 10%	14655	WMF1S68
C02	70651	CAPACITR 25 MF 25V		5C0D256G025CB7
C03	70651	CAPACITR 25 MF 25V		5C0D256G025CB7
C04	70613	CAPACITR 1 MF 200V MET MYLAR, OVAL	84411	X663F
C05	70539	CAPACITR 470 PF 500V SILVER MICA 5%	14655	CD19FD471J03
C06	73494	CAPACITR 22 PF 500V SILVER MICA 5%	14655	CD15ED220J03
C07	77319	CAPACITR .47 MF 200V MET MYLAR, OVAL	84411	X663F ECP07SB3 BKT
C08	70539	CAPACITR 470 PF 500V SILVER MICA 5%	14655	CD19FD471J03
C09	73494	CAPACITR 22 PF 500V SILVER MICA 5%	14655	CD15ED220J03
C10	70590	CAPACITR .1 MF 100V MYLAR 10%	14655	WMF1P1E
C11	70590	CAPACITR .1 MF 100V MYLAR 10%	14655	WMF1P1E
C12	70539	CAPACITR 470 PF 500V SILVER MICA 5%	14655	CD19FD471J03
C13	73494	CAPACITR 22 PF 500V SILVER MICA 5%	14655	CD15ED220J03
R01	71977	RESISTOR 2.2K OHM 1/4W 10% COMP		GB2221
R02	71887	RESISTOR 100 OHM 1/4W 10% COMP		CB1011
R03	71887	RESISTOR 100 OHM 1/4W 10% COMP		CB1011
R04	71977	RESISTOR 2.2K OHM 1/4W 10% COMP		GB2221
R05	71966	RESISTOR 1.5K OHM 1/4W 10% COMP		GB1521
R06	72026	RESISTOR 10K OHM 1/4W 10% COMP		GB1031
R07	72159	RESISTOR 390K OHM 1/4W 10% COMP		GB3941
R08	71862	RESISTOR 47 OHM 1/4W 10% COMP		CB4701
R09	72026	RESISTOR 10K OHM 1/4W 10% COMP		GB1031
R10	71977	RESISTOR 2.2K OHM 1/4W 10% COMP		GB2221
R11	71977	RESISTOR 2.2K OHM 1/4W 10% COMP		GB2221
R12	71966	RESISTOR 1.5K OHM 1/4W 10% COMP		GB1521
R13	71862	RESISTOR 47 OHM 1/4W 10% COMP		CB4701
R14	72002	RESISTOR 4.7K OHM 1/4W 10% COMP		GB4721
R15	71941	RESISTOR 820 OHM 1/4W 10% COMP		GB8211
R16	76599	POT 500 OHM 1W WW 20T PC MT	80294	3006P-1-501
R17	72039	RESISTOR 15K OHM 1/4W 10% COMP		GB1531
R18	71966	RESISTOR 1.5K OHM 1/4W 10% COMP		GB1521
R19	71862	RESISTOR 47 OHM 1/4W 10% COMP		CB4701

PARTS LIST ASSY REFERENCE LIMITER CIRCUIT

1833 DRAWING NO 7-4 REF DESIG PREFIX A1A3, A11A3

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
R20	72068	RESISTOR 39K OHM 1/4W 10% COMP		GB3931
R21	71977	RESISTOR 2.2K OHM 1/4W 10% COMP		GB2221
U01	77581	IC OP AMPL 709C EQ	13715	U5B770939X
U02	77581	IC OP AMPL 709C EQ	13715	U5B770939X
U03	77581	IC OP AMPL 709C EQ	13715	U5B770939X

PARTS LIST ASSY LIN/LOG AMPLIFIER

1833 DRAWING NO 7-5 REF DESIG PREFIX A1A4, A11A4

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
CR01	71111	DIODE 1N459A SIL 175V 40MA	80368	1N459A
C01	70590	CAPACITR .1 MF 100V MYLAR 10%	14655	WMF1P1E
C02	70590	CAPACITR .1 MF 100V MYLAR 10%	14655	WMF1P1E
C03	73500	CAPACITR .0015 MF 100V MYLAR 10%	14655	WMF1D15
R01	78907	RESISTOR 5.90K OHM 1/4W 1% MTL FLM		RN60D5901F
R02	78249	RESISTOR 11.8K OHM 1/4W 1% MTL FLM		RN60D1182F
R03	71951	RESISTOR 1.0K OHM 1/4W 10% COMP		GB1021
R04	71951	RESISTOR 1.0K OHM 1/4W 10% COMP		GB1021
R05	78579	RESISTOR 75.0K OHM 1/4W 1% MTL FLM		RN60D7502F
R06	76979	POT 20K OHM 1W WW 20T PC MT	80294	3006P-1-203
R07	78456	RESISTOR 60.4K OHM 1/4W 1% MTL FLM		RN60D6042F
R08	76595	POT 1K OHM 1W WW PC MT 20T	80294	3006P-1-102
R09	78573	RESISTOR 3.74K OHM 1/4W 1% MTL FLM		RN60D
R10	78573	RESISTOR 3.74K OHM 1/4W 1% MTL FLM		RN60D
R11	72084	RESISTOR 50.0K OHM 1/4W 1% DEP CAR	91637	DC-1/4
R12	76596	POT 10K OHM 1W WW 20T PC MT	80294	3006P-1-103
R13	71862	RESISTOR 47 OHM 1/4W 10% COMP		CB4701
R14	78246	RESISTOR 10.0K OHM 1/4W 1% MTL FLM		RN60D1002F
R15	76596	POT 10K OHM 1W WW 20T PC MT	80294	3006P-1-103
R16	78248	RESISTOR 1.00K OHM 1/4W 1% MTL FLM		RN60D1001F
R17	78246	RESISTOR 10.0K OHM 1/4W 1% MTL FLM		RN60D1002F
R18	71951	RESISTOR 1.0K OHM 1/4W 10% COMP		GB1021
R19	71837	RESISTOR 100 OHM 1/4W 10% COMP		CB1011
R20	78885	RESISTOR 768 OHM 1/4W 1% MTL FLM		RN60D7680F
R21	76595	POT 1K OHM 1W WW PC MT 20T	80294	3006P-1-102
R22	78238	RESISTOR 499 OHM 1/4W 1% MTL FLM		RN60D499OF
R23	76595	POT 1K OHM 1W WW PC MT 20T	80294	3006P-1-102
R24	78576	RESISTOR 8.25K OHM 1/4W 1/8W 1% MTL FLM		RN60D8251F
R25	76980	POT 5K OHM 1W WW 20T PC MT	80294	3006P-1-502
R26	78928	RESISTOR 100K OHM 1/10W 1% MTL FLM		RN55C1003F
R27	78230	POT 200 OHM 1W WW 20T PC MT	80294	3006P-1-201
U01	78220	AMPLIFIR OPERATIONAL	02335	ADO-27B
U02	78219	IC TEMP CONT DIFF PAIR 726C EQ	13715	U5J772632X
U03	78977	IC OP AMPL INTL COMPEN 741C EQ	13715	U5B7741393

PARTS LIST ASSY LIN/LOG AMPLIFIER

1833 DRAWING NO 7-5 REF DESIG PREFIX A1A4, A11A4

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
U04	78977	IC OP AMPL INTL COMPEN 741C EQ	13715	U5B7741393

PARTS LIST ASSY INTERCONNECT & 6.4 MHZ OSCILLATOR

1833 DRAWING NO 7-6 REF DESIG PREFIX A1A5, A11A5

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
AC1	113731	CONTROL LOGIC ASSEMBLY		
AO2	91977	INTEGRATOR		
C01	80139	CAPACITR .1 MF 50V CER SQUARE	72982	8131-MC5C-651-104Z
C02	81525	CAPACITR .003 MF 500V SILVER MICA 5%		CM06FD302J03
C03	70551	CAPACITR .002 MF 500V MOLDED SIL MICA 2%	84171	CM20E-2026
L01	78718	INDUCTOR .429-.517 UH PC MOUNT	71279	7107-09
R01	71836	RESISTOR 10 OHM 1/4W 10% COMP		CB1001
U01	80443	IC TTL HEX INVERTER	01295	SN7404N
XA01	78279	CONNECTR 22 PIN DOUBLE READOUT	71785	252-22-30-160
XA02	78279	CONNECTR 22 PIN DOUBLE READOUT	71785	252-22-30-160

PARTS LIST ASSY CONTROL LOGIC

1833 DRAWING NO 7-7 REF DESIG PREFIX A1A5A1, A11A5A1

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
CR01	71110	DIODE 1N277 GER 100V 75MA	80368	1N277
CR02	71110	DIODE 1N277 GER 100V 75MA	80368	1N277
CR03	71110	DIODE 1N277 GER 100V 75MA	80368	1N277
CR04	71110	DIODE 1N277 GER 100V 75MA	80368	1N277
CR05	71110	DIODE 1N277 GER 100V 75MA	80368	1N277
C01	79730	CAPACITR 27 MF 10V SOLID TANT POL 10%	05397	CS13BC276
C02	70536	CAPACITR 390 PF 500V SILVER MICA 5%	14655	CD15FD391J03
C03	70517	CAPACITR 100 PF 500V SILVER MICA 5%	14655	CD15FD101J03
C04	70629	CAPACITR 6.8 MF 35V SOLID TANT POL 10%	80183	164D-685X9035B2
J01	78279	CONNECTR 22 PIN DOUBLE READOUT	71785	252-22-30-160
L01	70737	INDUCTOR 22 UH SUBMIN UNSHLD MOLDED 10%	76493	9340-28
Q01	78553	TRANSSTR 2N4870 SIL UNIJUNCTION PN	80211	2N4870
Q02	77147	TRANSSTR 2N3947 NPN SIL	80211	2N3947
R01	72019	RESISTOR 8.2K OHM 1/4W 10% COMP		GB8221
R02	72019	RESISTOR 8.2K OHM 1/4W 10% COMP		GB8221
R03	72019	RESISTOR 8.2K OHM 1/4W 10% COMP		GB8221
R04	72019	RESISTOR 8.2K OHM 1/4W 10% COMP		GB8221
R05	72019	RESISTOR 8.2K OHM 1/4W 10% COMP		GB8221
R06	72019	RESISTOR 8.2K OHM 1/4W 10% COMP		GB8221
R07	71951	RESISTOR 1.0K OHM 1/4W 10% COMP		GB1021
R08	72088	RESISTOR 56K OHM 1/4W 10% COMP		GB5631
R09	71887	RESISTOR 100 OHM 1/4W 10% COMP		GB1011
R10	72014	RESISTOR 6.8K OHM 1/4W 10% COMP		GB6821
R11	71918	RESISTOR 330 OHM 1/4W 10% COMP		GB3311
R12	72019	RESISTOR 8.2K OHM 1/4W 10% COMP		GB8221
R13	72014	RESISTOR 6.8K OHM 1/4W 10% COMP		GB6821
R14	72019	RESISTOR 8.2K OHM 1/4W 10% COMP		GB8221
U01	79442	IC DTL DUAL J-K CLOCKED FLIP-FLOP	12040	DM9094N
U02	76702	IC DTL QUAD 2-IN NAND GATE	27318	SN946-2P
U03	76778	IC TTL PRESET DECADE COUNTER	18324	N8280A
U04	76702	IC DTL QUAD 2-IN NAND GATE	27318	SN946-2P

PARTS LIST ASSY CONTROL LOGIC

1833 DRAWING NO 7-7 REF DESIG PREFIX A1A5A1, A11A5A1

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
U05	76699	IC DTL TRIPLE 3-IN NAND GATE	27318	SN962-2P
U06	79441	IC DTL HEX INVERTER	27318	936-2P
U07	76778	IC TTL PRESET DECADE COUNTER	18324	N8280A
U08	76701	IC DTL EXP DUAL 4-IN NAND GATE	27318	SN930-2P
U09	76701	IC DTL EXP DUAL 4-IN NAND GATE	27318	SN930-2P
U10	76702	IC DTL QUAD 2-IN NAND GATE	27318	SN946-2P
U11	76778	IC TTL PRESET DECADE COUNTER	18324	N8280A
U12	76701	IC DTL EXP DUAL 4-IN NAND GATE	27318	SN930-2P
U13	79441	IC DTL HEX INVERTER	27318	936-2P
U14	79442	IC DTL DUAL J-K CLOCKED FLIP-FLOP	12040	DM9094N
U15	76778	IC TTL PRESET DECADE COUNTER	18324	N8280A
U16	79445	IC DTL EXP DUAL 4-IN BUFFER	27318	932-2P
U17	76698	IC DTL DUAL 4-IN PWR NAND GATE	27318	SN944-2P
U18	76702	IC DTL QUAD 2-IN NAND GATE	27318	SN946-2P
U19	79442	IC DTL DUAL J-K CLOCKED FLIP-FLOP	12040	DM9094N
U20	76778	IC TTL PRESET DECADE COUNTER	18324	N8280A
U21	76778	IC TTL PRESET DECADE COUNTER	18324	N8280A
U22	76778	IC TTL PRESET DECADE COUNTER	18324	N8280A
U23	79443	IC TTL QUAD BISTABLE LATCH	18324	N7475B
U24	79443	IC TTL QUAD BISTABLE LATCH	18324	N7475B
U25	79443	IC TTL QUAD BISTABLE LATCH	18324	N7475B
U26	79443	IC TTL QUAD BISTABLE LATCH	18324	N7475B
U27	76702	IC DTL QUAD 2-IN NAND GATE	27318	SN946-2P
U28	79442	IC DTL DUAL J-K CLOCKED FLIP-FLOP	12040	DM9094N
U29	76702	IC DTL QUAD 2-IN NAND GATE	27318	SN946-2P
W01	11498C	CABLE DISPLAY		

PARTS LIST ASSY DUAL-SLOPE INTEGRATOR

1833 DRAWING NO 7-8 REF DESIG PREFIX A1A5A2, A11A5A2

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
CR01	79658	DIODE 1N938 TC REF 9.0V .001% .5W	80211	1N938
CR02	71111	DIODE 1N459A SIL 175V 40MA	80368	1N459A
CR03	79658	DIODE 1N938 TC REF 9.0V .001% .5W	80211	1N938
CR04	71142	DIODE 1N4154 SIL 25V 150MA	80368	1N4154
CR05	71142	DIODE 1N4154 SIL 25V 150MA	80368	1N4154
CR06	71142	DIODE 1N4154 SIL 25V 150MA	80368	1N4154
CR07	71142	DIODE 1N4154 SIL 25V 150MA	80368	1N4154
CR08	71142	DIODE 1N4154 SIL 25V 150MA	80368	1N4154
CR09	71142	DIODE 1N4154 SIL 25V 150MA	80368	1N4154
CR10	71142	DIODE 1N4154 SIL 25V 150MA	80368	1N4154
CR11	71142	DIODE 1N4154 SIL 25V 150MA	80368	1N4154
CR12	71142	DIODE 1N4154 SIL 25V 150MA	80368	1N4154
CR13	71142	DIODE 1N4154 SIL 25V 150MA	80368	1N4154
C01	70589	CAPACITR .1 MF 50V CER DISC	71590	CK104
C02	70589	CAPACITR .1 MF 50V CER DISC	71590	CK104
C03	70589	CAPACITR .1 MF 50V CER DISC	71590	CK104
C04	75417	CAPACITR .01 MF 150V CER DISC	71590	DDM-103
C05	77713	CAPACITR .005 MF 50V CER DISC	71590	CK-502
C06	70589	CAPACITR .1 MF 50V CER DISC	71590	CK104
C07	70618	CAPACITR 2 MF 200V MET MYLAR, CVAL	84411	X663F
C08	73505	CAPACITR .033 MF 100V MYLAR 10%	14655	WMF1S33
C09	73507	CAPACITR .15 MF 100V MYLAR 10%	14655	WMF1P15
C10	70570	CAPACITR .02 MF 100V DIPPED MYLAR	84171	ICP 1 203
C11	70529	CAPACITR 220 PF 500V SILVER MICA 5%	14655	CD15FD221J03
C12	70589	CAPACITR .1 MF 50V CER DISC	71590	CK104
C13	70498	CAPACITR 47 PF 500V SILVER MICA 5%	14655	CD15ED470J03
C14	75417	CAPACITR .01 MF 150V CER DISC	71590	DDM-103
C15	75417	CAPACITR .01 MF 150V CER DISC	71590	DDM-103
C16	75417	CAPACITR .01 MF 150V CER DISC	71590	DDM-103
C17	77713	CAPACITR .005 MF 50V CER DISC	71590	CK-502
C18	75417	CAPACITR .01 MF 150V CER DISC	71590	DDM-103
C19	70589	CAPACITR .1 MF 50V CER DISC	71590	CK104
IC01	79441	IC DTL HEX INVERTER	27318	936-2P
IC02	76702	IC DTL QUAD 2-IN NAND GATE	27318	SW946-2P
IC03	76778	IC TTL PRESET DECADE COUNTER	18324	N8280A

PARTS LIST ASSY DUAL-SLOPE INTEGRATOR

1833 DRAWING NO 7-8 REF DESIG PREFIX A1A5A2, A11A5A2

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
IC04	76778	IC TTL PRESET DECADE COUNTER	18324	N8280A
IC05	76702	IC DTL QUAD 2-IN NAND GATE	27318	Sn946-2P
IC06	79442	IC DTL DUAL J-K CLOCKED FLIP-FLOP	12040	DM9094N
IC07	79442	IC DTL DUAL J-K CLOCKED FLIP-FLOP	12040	DM9094N
IC08	79442	IC DTL DUAL J-K CLOCKED FLIP-FLOP	12040	DM9094N
IC09	76702	IC DTL QUAD 2-IN NAND GATE	27318	Sn946-2P
IC10	79441	IC DTL HEX INVERTER	27318	936-2P
IC11	79442	IC DTL DUAL J-K CLOCKED FLIP-FLOP	12040	DM9094N
IC12	79442	IC DTL DUAL J-K CLOCKED FLIP-FLOP	12040	DM9094N
IC13	76702	IC DTL QUAD 2-IN NAND GATE	27318	Sn946-2P
IC14	78760	IC OP AMPL HIGH PERFORMANCE	24355	8C1A
IC15	79661	IC DIFF COMPARATOR 710C EQ	80211	MC1710CG
L01	75235	INDUCTOR 8.2 UH SUBMIN UNSHLD MOLDED 10%	76493	9310-34
L02	75235	INDUCTOR 8.2 UH SUBMIN UNSHLD MOLDED 10%	76493	9310-34
L03	75235	INDUCTOR 8.2 UH SUBMIN UNSHLD MOLDED 10%	76493	9310-34
Q01	77148	TRANSSTR 2N3251 PNP SIL	80211	2N3251
Q02	76446	TRANSSTR 2N4222 FET N-CHNL JUNC	80211	2N4222
Q03	76446	TRANSSTR 2N4222 FET N-CHNL JUNC	80211	2N4222
Q04	77148	TRANSSTR 2N3251 PNP SIL	80211	2N3251
Q05	77148	TRANSSTR 2N3251 PNP SIL	80211	2N3251
Q06	77148	TRANSSTR 2N3251 PNP SIL	80211	2N3251
Q07	76446	TRANSSTR 2N4222 FET N-CHNL JUNC	80211	2N4222
Q08	77148	TRANSSTR 2N3251 PNP SIL	80211	2N3251
Q09	77147	TRANSSTR 2N3947 NPN SIL	80211	2N3947
Q10	77148	TRANSSTR 2N3251 PNP SIL	80211	2N3251
Q11	77147	TRANSSTR 2N3947 NPN SIL	80211	2N3947
Q12	77147	TRANSSTR 2N3947 NPN SIL	80211	2N3947
R01	72019	RESISTOR 8.2K OHM 1/4W 10% COMP		GB8221
R02	72019	RESISTOR 8.2K OHM 1/4W 10% COMP		GB8221
R03	72019	RESISTOR 8.2K OHM 1/4W 10% COMP		GB8221
R04	78572	RESISTOR 3.32K OHM 1/4W 1% MTL FLM		RN60D3321F
R05	78885	RESISTOR 768 OHM 1/4W 1% MTL FLM		RN60D7680F
R06	78247	RESISTOR 4.53K OHM 1/4W 1% MTL FLM		RN60D4531F
R07	78246	RESISTOR 10.0K OHM 1/4W 1% MTL FLM		RN60D1002F

PARTS LIST ASSY DUAL-SLOPE INTEGRATOR

1833 DRAWING NO 7-8 REF DESIG PREFIX A1A5A2, A11A5A2

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
R08	78885	RESISTOR 768 OHM 1/4W 1% MTL FLM		RN60D7680F
R09	76596	POT 10K OHM 1W WW 20T PC MT	80294	3005P-1-103
R10	78578	RESISTOR 36.5K OHM 1/4W 1% MTL FLM		RN60D3652F
R11	76596	POT 10K OHM 1W WW 20T PC MT	80294	3005P-1-103
R12	79638	RESISTOR 226K OHM 1/4W 1% MTL FLM		RN60D2263F
R13	78579	RESISTOR 75.0K OHM 1/4W 1% MTL FLM		RN60D7502F
R14	79652	RESISTOR 909K OHM 1/4W 1% MTL FLM		RN60D9093F
R15	72054	RESISTOR 22K OHM 1/4W 10% COMP		GB2231
R16	72054	RESISTOR 22K OHM 1/4W 10% COMP		GB2231
R17	72026	RESISTOR 10K OHM 1/4W 10% COMP		GB1031
R18	72026	RESISTOR 10K OHM 1/4W 10% COMP		GB1031
R19	72113	RESISTOR 100K OHM 1/4W 10% COMP		GB1041
R20	72113	RESISTOR 100K OHM 1/4W 10% COMP		GB1041
R21	72054	RESISTOR 22K OHM 1/4W 10% COMP		GB2231
R22	72054	RESISTOR 22K OHM 1/4W 10% COMP		GB2231
R23	72054	RESISTOR 22K OHM 1/4W 10% COMP		GB2231
R24	72113	RESISTOR 100K OHM 1/4W 10% COMP		GB1041
R25	79653	RESISTOR 162K OHM 1/4W 1% MTL FLM		RN60D1623F
R26	72026	RESISTOR 10K OHM 1/4W 10% COMP		GB1031
R27	79654	RESISTOR 84.5K OHM 1/4W 1% MTL FLM		RN60D8452F
R28	71966	RESISTOR 1.5K OHM 1/4W 10% COMP		GB1521
R29	71862	RESISTOR 47 OHM 1/4W 10% COMP		CB4701
R30	71862	RESISTOR 47 OHM 1/4W 10% COMP		CB4701
R31	72054	RESISTOR 22K OHM 1/4W 10% COMP		GB2231
R32	71862	RESISTOR 47 OHM 1/4W 10% COMP		CB4701
R33	78246	RESISTOR 10.0K OHM 1/4W 1% MTL FLM		RN60D1002F
R34	78246	RESISTOR 10.0K OHM 1/4W 1% MTL FLM		RN60D1002F
R35	72116	RESISTOR 120K OHM 1/4W 10% COMP		GB1241
R36	72002	RESISTOR 4.7K OHM 1/4W 10% COMP		GB4721
R37	72064	RESISTOR 33K OHM 1/4W 10% COMP		GB3331
R38	72014	RESISTOR 6.8K OHM 1/4W 10% COMP		GB6821
R39	72026	RESISTOR 10K OHM 1/4W 10% COMP		GB1031
R40	71982	RESISTOR 2.7K OHM 1/4W 10% COMP		GB2721
R41	72034	RESISTOR 12K OHM 1/4W 10% COMP		GB1231
R42	78723	POT 10K OHM 1/2W CERMET PC MT	01121	SV1031
R43	71977	RESISTOR 2.2K OHM 1/4W 10% COMP		GB2221
R44	71862	RESISTOR 47 OHM 1/4W 10% COMP		CB4701

PARTS LIST ASSY DUAL-SLOPE INTEGRATOR

1833 DRAWING NO 7-8 REF DESIG PREFIX A1A5A2, A11A5A2

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
R45	72054	RESISTOR 22K OHM 1/4W 10% COMP		GB2231
R46	72014	RESISTOR 6.8K OHM 1/4W 10% COMP		GB6821
R47	72026	RESISTOR 10K OHM 1/4W 10% COMP		GB1031
R48	72002	RESISTOR 4.7K OHM 1/4W 10% COMP		GB4721
R49	72019	RESISTOR 8.2K OHM 1/4W 10% COMP		GB8221
R50	72019	RESISTOR 8.2K OHM 1/4W 10% COMP		GB8221
R51	72019	RESISTOR 8.2K OHM 1/4W 10% COMP		GB8221

PARTS LIST ASSY DIGITAL DISPLAY

1833 DRAWING NO 7-9 REF DESIG PREFIX A2, A12

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
C01	70569	CAPACITR .01 MF 1KV CER DISC	71590	DD1032
DS01	79438	TUBE ELEC 5750 NIXIE	83594	TYPE 5750
DS02	79438	TUBE ELEC 5750 NIXIE	83594	TYPE 5750
DS03	79438	TUBE ELEC 5750 NIXIE	83594	TYPE 5750
DS04	79438	TUBE ELEC 5750 NIXIE	83594	TYPE 5750
J01	81537	SOCKET DUAL IN-LINE 14 PIN PC MT		314-AG5D-R
J02	81537	SOCKET DUAL IN-LINE 14 PIN PC MT		314-AG5D-R
Q01	76293	TRANSSTR 2N3440 NPN SIL	79089	2N3440
Q02	76293	TRANSSTR 2N3440 NPN SIL	79089	2N3440
R01	72064	RESISTOR 33K OHM 1/4W 10% COMP		GB3331
R02	72064	RESISTOR 33K OHM 1/4W 10% COMP		GB3331
R03	72064	RESISTOR 33K OHM 1/4W 10% COMP		GB3331
R04	72064	RESISTOR 33K OHM 1/4W 10% COMP		GB3331
R05	72077	RESISTOR 47K OHM 1/4W 10% COMP		GB4731
R06	72176	RESISTOR 680K OHM 1/4W 10% COMP		GB6841
R07	72059	RESISTOR 27K OHM 1/4W 10% COMP		GB2731
R08	72099	RESISTOR 82K OHM 1/4W 10% COMP		GB8231
R09	72114	RESISTOR 100K OHM 1W 10% COMP		GB1041
R10	72077	RESISTOR 47K OHM 1/4W 10% COMP		GB4731
R11	71995	RESISTOR 3.9K OHM 1/2W 10% COMP		EB3921
U01	79444	IC TTL BCD-DEC DECODER/DRIVER	18324	N7441B
U02	79444	IC TTL BCD-DEC DECODER/DRIVER	18324	N7441B
U03	79444	IC TTL BCD-DEC DECODER/DRIVER	18324	N7441B
U04	79444	IC TTL BCD-DEC DECODER/DRIVER	18324	N7441B
U05	79444	IC TTL BCD-DEC DECODER/DRIVER	18324	N7441B

PARTS LIST ASSY BCD OUTPUT, OPTION -1*

1833 DRAWING NO 7-10 REF DESIG PREFIX A3, A13

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
C01	80139	CAPACITR .1 MF 50V CER SQUARE	72982	8131-M05C-651-104Z
C02	80139	CAPACITR .1 MF 50V CER SQUARE	72982	8131-M05C-651-104Z
J01	79634	CONN RECT 50-CONC FEM CHASSIS MT W/LOCK	C266C	57-40500
L01	75235	INDUCTOR 8.2 UH SUBMIN UNSHLD MOLDED 10%	76493	9310-34
P01	99091	BOARD PC		
U01	79441	IC DTL HEX INVERTER	27318	936-2P
U02	79441	IC DTL HEX INVERTER	27318	936-2P
U03	79441	IC DTL HEX INVERTER	27318	936-2P
U04	79441	IC DTL HEX INVERTER	27318	936-2P
U05	79441	IC DTL HEX INVERTER	27318	936-2P
U06	79441	IC DTL HEX INVERTER	27318	936-2P

*SEE PARAGRAPH 6.4

PARTS LIST ASSY PCB BYTE OUTPUT, OPTION-4

1 33 DRAWING NO 7-11 REF DESIG PREFIX A3*

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
J01	79634	CONN RECT 50-COND FEM CHASSIS MT W/LOCK	02660	57-40500
P01	99091	BOARD PC		
R01	71977	RESISTOR 2.2K OHM 1/4W 10% COMP	01121	RCR07G222KS
R02	71977	RESISTOR 2.2K OHM 1/4W 10% COMP	01121	RCR07G222KS
R03	71977	RESISTOR 2.2K OHM 1/4W 10% COMP	01121	RCR07G222KS
R04	71977	RESISTOR 2.2K OHM 1/4W 10% COMP	01121	RCR07G222KS
R05	71977	RESISTOR 2.2K OHM 1/4W 10% COMP	01121	RCR07G222KS
R06	71977	RESISTOR 2.2K OHM 1/4W 10% COMP	01121	RCR07G222KS
R07	71977	RESISTOR 2.2K OHM 1/4W 10% COMP	01121	RCR07G222KS
R08	71977	RESISTOR 2.2K OHM 1/4W 10% COMP	01121	RCR07G222KS
R09	71977	RESISTOR 2.2K OHM 1/4W 10% COMP	01121	RCR07G222KS
R10	71977	RESISTOR 2.2K OHM 1/4W 10% COMP	01121	RCR07G222KS
R11	71977	RESISTOR 2.2K OHM 1/4W 10% COMP	01121	RCR07G222KS
R12	72014	RESISTOR 6.8K OHM 1/4W 10% COMP	01121	RCR07G682KS
R13	72014	RESISTOR 6.8K OHM 1/4W 10% COMP	01121	RCR07G682KS
U01	80510	IC DTL QUAD 2-IN POWER NAND GATE	80211	MC858P
U02	80510	IC DTL QUAD 2-IN POWER NAND GATE	80211	MC858P
U03	80510	IC DTL QUAD 2-IN POWER NAND GATE	80211	MC858P
U04	80510	IC DTL QUAD 2-IN POWER NAND GATE	80211	MC858P
U05	80510	IC DTL QUAD 2-IN POWER NAND GATE	80211	MC858P

*SEE PARAGRAPH 6.4

PARTS LIST ASSY I.PUT AMPLIFIER/DISPLAY CONTROL, P/N 115545, 115546*

1833 DRAWING NC 7-12 REF DESIG PREFIX A4, A14 STD*

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
C01	73497	CAPACITR 180 PF 500V SILVER MICA 5%	14655	CD15FD181J03
C02	77713	CAPACITR .005 MF 50V CER DISC	71590	CK-502
C03	76696	CAPACITR .01 MF 500V SILVER MICA 5%	14655	CD30FD103J03
C04	75200	CAPACITR .0024 MF 500V SILVER MICA 5%	84171	DM19 242J
C05	76696	CAPACITR .01 MF 500V SILVER MICA 5%	14655	CD30FD103J03
C06	75200	CAPACITR .0024 MF 500V SILVER MICA 5%	84171	DM19 242J
C07	76932	CAPACITR .0036 MF 500V SILVER MICA 5%	14655	CD19FD362J03
C08	78217	CAPACITR .33 MF 50V MYLAR MICRO FLAT	24446	65F16AA334
J01	80987	CONN COAX BNC FEM TO CUP SHELL ISOLATED		4890-7 NT-34 PLATING
J02	76460	CONN COAX BNC FEM TO .110 CBL CRIMP D-HL	02660	31-318
P01	77589	CONN COAX 27 THREADED FEM PT ANG .17 CBL	02660	27-26
P02	81542	PLUG DUAL IN LINE 16 PIN	91506	1P16-1
R01	78472	RESISTOR 10 OHM 1/5W .1% RADIAL LEADS	01686	R-451
R02	78471	RESISTOR 99.8K OHM 1/5W .1% RADIAL LEADS	01686	R-451
R03	71862	RESISTOR 47 OHM 1/4W 10% COMP	01121	RCR07G470KS
R03#	78341	POT 50K OHM 2W WW 10T	80294	3507S-1-503
R04	71966	RESISTOR 1.5K OHM 1/4W 10% COMP	01121	RCR07G152KS
R05	76197	RESISTOR 16.0K OHM 1/4W 1% DEP CAR	91637	DC-1/4
R06	80209	RESISTOR 64.9K OHM 1/8W 1% MTL FILM		RN55D6492F
R07	78918	RESISTOR 806 OHM 1/10W 1% MTL FLM		RN55C8060F
R08	76596	POT 10K OHM 1W WW 20T PC MT	80294	3C05P-1-103
R09	80723	RESISTOR 3.01K OHM 1/4W 1% MTL FLM		RN60D3011F
R10	78576	RESISTOR 8.25K OHM 1/4W 1/8W 1% MTL FLM		RN60D8251F
R11	76598	POT 2K OHM 1W WW 20T PC MT	80294	3C05P-1-202
R12	80207	RESISTOR 44.2K OHM 1/8W 1% MTL FILM		RN55D4422F
S01**	79573	SWITCH ROT 4P 2-6 POS NSH 2 SEC SUBMIN	71590	PSA-211
S02	79108	SWITCH ROT 2P 2-6 POS NSH SUBMIN	71590	PSA-203
S03	72895	SWITCH BUTTON SPDT BREAK MAKE BLACK	82389	913BU
U01	77581	IC OP AMPL 709C EQ	13715	U5B770939X

*SEE PARAGRAPH 6.4
**EXCLUDED ON MODEL 1833-10
#FRONT PANEL GAIN CONTROL

PARTS LIST ASSY PREAMPLIFIER/DISPLAY CONTROL, P/N 115505, 115547*

1833 DRAWING NO 7-13 REF DESIG PREFIX A4,A14 OPT -2*

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
A01	46874	BOARD PC ASSY PREAMPLIFIER CBA		
C01	79003	CAPACITR 100 MF 15V	80183	5C0D107G016DC7
C02	77920	CAPACITR 1 MF 25V CER .5X.5X.16 THK	80183	5C023105X025083
C03	77920	CAPACITR 1 MF 25V CER .5X.5X.16 THK	80183	5C023105X025083
J01	80987	CONN COAX BNC FEM TO CUP SHELL ISOLATED		4890-7 NT-34 PLATING
J02	76460	CONN COAX BNC FEM TO .110 CBL CRIMP D-HL	02660	31-318
P01	77589	CONN COAX 27 THREADED FEM RT ANG .12 CBL	02660	27-26
P02	77589	CONN COAX 27 THREADED FEM RT ANG .12 CBL	02660	27-26
R01	78472	RESISTOR 10 OHM 1/5W .1% RADIAL LEADS	01686	R-451
R02	78471	RESISTOR 99.8K OHM 1/5W .1% RADIAL LEADS	01686	R-451
R03	78341	POT 50K OHM 2W WW 10T	80294	3507S-1-503
R04	81540	POT 20K OHM 1W WW PNL MT	80294	3255L-1-203M
S01**	79573	SWITCH ROT 4P 2-6 POS NSH 2 SEC SUBMIN	71590	PSA-211
S02	77280	SWITCH TOG DPDT AC-DC MIN	09353	7201
S03	72895	SWITCH BUTTON SPDT BREAK MAKE BLACK	82389	913BU
T01	81539	XFMR PRI 10K 1MADC SEC 500CT 100MW	07388	23150

*SEE PARAGRAPH 6.4

**EXCLUDED ON MODEL 1833-10

PREAMPLIFIER ASSEMBLY, INCL W/OPTION-2

REF DESIG PREFIX A4A1, A14A1

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
C01	70629	CAPACITR 6.8 MF 35V SOLID TANT POL 10%	80183	164D-685X9035B2
C02	78217	CAPACITR .33 MF 50V MYLAR MICRO FLAT	24446	65F16AA334
C03	70629	CAPACITR 6.8 MF 35V SOLID TANT POL 10%	80183	164D-685X9035B2
C04	78217	CAPACITR .33 MF 50V MYLAR MICRO FLAT	24446	65F16AA334
C05	70629	CAPACITR 6.8 MF 35V SOLID TANT POL 10%	80183	164D-685X9035B2
C06	70498	CAPACITR 47 PF 500V SILVER MICA 5%	14655	CD15ED470J03
C07	73497	CAPACITR 180 PF 500V SILVER MICA 5%	14655	CD15FD181J03
C08	70498	CAPACITR 47 PF 500V SILVER MICA 5%	14655	CD15ED470J03
C09	80139	CAPACITR .1 MF 50V CER SQUARE	72982	8131-M050-651-104Z
C10	80139	CAPACITR .1 MF 50V CER SQUARE	72982	8131-M050-651-104Z
Q01	78215	TRANSSTR 2N5089 NPN SIL	80211	2N5089
Q02	78214	TRANSSTR 2N5087 PNP SIL	80211	2N5087
Q03	78215	TRANSSTR 2N5089 NPN SIL	80211	2N5089
Q04	78214	TRANSSTR 2N5087 PNP SIL	80211	2N5087
Q05	78215	TRANSSTR 2N5089 NPN SIL	80211	2N5089
Q06	78214	TRANSSTR 2N5087 PNP SIL	80211	2N5087
R01	79722	RESISTOR 90.9K OHM RN55C/D 1% MTL FLM		RN55C9092F
R02	78933	RESISTOR 10.0K OHM RN55C/D 1% MTL FLM		RN55C1002F
R03	79010	RESISTOR 590 OHM RN55C/D 1% MTL FLM		RN55C5900F
R04	82117	RESISTOR 5.62K OHM RN60C/D 1% MTL FLM		RN60C5621F
R05	72051	RESISTOR 20.0K OHM 1/8W 1% DEP CAR	91637	MC-1/8
R06	78931	RESISTOR 4.99K OHM RN55C/D 1% MTL FLM		RN55C4991F
R07	78700	FACTORY SELECTED VALUE		
R08	79722	RESISTOR 90.9K OHM RN55C/D 1% MTL FLM		RN55C9092F
R09	78933	RESISTOR 10.0K OHM RN55C/D 1% MTL FLM		RN55C1002F
R10	78930	RESISTOR 2.21K OHM 1/10W 1% MTL FLM		RN55C2211F
R11	82117	RESISTOR 5.62K OHM RN60C/D 1% MTL FLM		RN60C5621F
R12	72051	RESISTOR 20.0K OHM 1/8W 1% DEP CAR	91637	MC-1/8

PREAMPLIFIER ASSEMBLY, INCL W/OPTION-2

REF DESIG PREFIX A4A1, A14A1

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
R13	78931	RESISTOR 4.99K OHM RN55C/D 1% MTL FLM		RN55C4991F
R14	78600	NOT ASSIGNED		
R15	78933	RESISTOR 10.0K OHM RN55C/D 1% MTL FLM		RN55C1002F
R16	79722	RESISTOR 90.9K OHM RN55C/D 1% MTL FLM		RN55C9092F
R17	78931	RESISTOR 4.99K OHM RN55C/D 1% MTL FLM		RN55C4991F
R18	82117	RESISTOR 5.62K OHM RN60C/D 1% MTL FLM		RN60C5621F
R19	72051	RESISTOR 20.0K OHM 1/8W 1% DEP CAR	91637	MC-1/8
R20	78931	RESISTOR 4.99K OHM RN55C/D 1% MTL FLM		RN55C4991F
R21	72011	RESISTOR 5.6K OHM 1/4W 10% COMP	01121	RCR07G562KS
R22	71993	RESISTOR 3.9K OHM 1/4W 10% COMP	01121	RCR07G392KS
R23	72011	RESISTOR 5.6K OHM 1/4W 10% COMP	01121	RCR07G562KS
S01	78213	SWITCH WAFER 2 P 5 POS NSH	71590	PS-23

PARTS LIST ASSY NOT ASSIGNED

1833 REF DESIG PREFIX A5

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
		NOT ASSIGNED		

PARTS LIST ASSY NOT ASSIGNED

1833 REF DESIG PREFIX A6

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
NOT ASSIGNED				

PARTS LIST ASSY NOT ASSIGNED

1833 REF DESIG PREFIX A7

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
		NOT ASSIGNED		

PARTS LIST ASSY NOT ASSIGNED

1833 REF DESIG PREFIX A8

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
		NOT ASSIGNED		

DIFFERENCE ASSEMBLY

REF DESIG PREFIX 10

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
CR01	71142	DIODE 1N4154 SIL 25V 150MA	80368	1N4154
CR02	71142	DIODE 1N4154 SIL 25V 150MA	80368	1N4154
CR03	71142	DIODE 1N4154 SIL 25V 150MA	80368	1N4154
CR04	71142	DIODE 1N4154 SIL 25V 150MA	80368	1N4154
CR05	71142	DIODE 1N4154 SIL 25V 150MA	80368	1N4154
CR06	71142	DIODE 1N4154 SIL 25V 150MA	80368	1N4154
C01	80139	CAPACITR .1 MF 50V CER SQUARE	72982	8131-M050-651-104Z
C02	80139	CAPACITR .1 MF 50V CER SQUARE	72982	8131-M050-651-104Z
C03	70517	CAPACITR 100 PF 500V SILVER MICA 5%	14655	CD15FD101J03
C04	80139	CAPACITR .1 MF 50V CER SQUARE	72982	8131-M050-651-104Z
C05	75417	CAPACITR .01 MF 150V CER DISC	71590	DDM-103
C06	80139	CAPACITR .1 MF 50V CER SQUARE	72982	8131-M050-651-104Z
C07	75417	CAPACITR .01 MF 150V CER DISC	71590	DDM-103
C08	75417	CAPACITR .01 MF 150V CER DISC	71590	DDM-103
C09	80139	CAPACITR .1 MF 50V CER SQUARE	72982	8131-M050-651-104Z
C10	80139	CAPACITR .1 MF 50V CER SQUARE	72982	8131-M050-651-104Z
Q01	79660	TRANSSTR 2N4093 FET N-CHNL JUNC	80211	2N4093
Q02	79660	TRANSSTR 2N4093 FET N-CHNL JUNC	80211	2N4093
Q03	79660	TRANSSTR 2N4093 FET N-CHNL JUNC	80211	2N4093
Q04	79660	TRANSSTR 2N4093 FET N-CHNL JUNC	80211	2N4093
Q05	77148	TRANSSTR 2N3251 PNP SIL	80211	2N3251
Q06	77148	TRANSSTR 2N3251 PNP SIL	80211	2N3251
Q07	76316	TRANSSTR 2N4036 PNP SIL	79089	2N4036
Q08	73140	TRANSSTR 2N2270 NPN SIL	79089	2N2270
Q09	77148	TRANSSTR 2N3251 PNP SIL	80211	2N3251
R01	78248	RESISTOR 1.00K OHM RN60C/D 1% MTL FLM		RN60C1001F
R02	80723	RESISTOR 3.01K OHM RN60C/D 1% MTL FLM		RN60C3011F
R03	76595	POT 1K OHM 1W WW PC MT 20T	80294	3005P-1-102

DIFFERENCE ASSEMBLY

REF DESIG PREFIX 10

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
R04	77164	RESISTOR 197 OHM 1/4W 1% DEP CAR	91637	DC-1/4
R05	80723	RESISTOR 3.01K OHM RN60C/D 1% MTL FLM		RN60C3011F
R06	72083	RESISTOR 50.0K OHM 1/8W 1% DEP CAR	91637	DC-1/8
R07	72083	RESISTOR 50.0K OHM 1/8W 1% DEP CAR	91637	DC-1/8
R08	72083	RESISTOR 50.0K OHM 1/8W 1% DEP CAR	91637	DC-1/8
R09	72083	RESISTOR 50.0K OHM 1/8W 1% DEP CAR	91637	DC-1/8
R10	80723	RESISTOR 3.01K OHM RN60C/D 1% MTL FLM		RN60C3011F
R11	78248	RESISTOR 1.00K OHM RN60C/D 1% MTL FLM		RN60C1001F
R12	76595	POT 1K OHM 1W WW PC MT 20T	80294	3005P-1-102
R13	77164	RESISTOR 197 OHM 1/4W 1% DEP CAR	91637	DC-1/4
R14	80723	RESISTOR 3.01K OHM RN60C/D 1% MTL FLM		RN60C3011F
R15	72026	RESISTOR 10K OHM 1/4W 10% COMP	01121	RCR07G103KS
R16	71951	RESISTOR 1.0K OHM 1/4W 10% COMP	01121	RCR07G102KS
R17	72026	RESISTOR 10K OHM 1/4W 10% COMP	01121	RCR07G103KS
R18	74696	RESISTOR 470 OHM 1/4W 5% COMP	01121	RCR07G471JS
R19	72138	RESISTOR 220K OHM 1/4W 10% COMP	01121	RCR07G224KS
R20	72054	RESISTOR 22K OHM 1/4W 10% COMP	01121	RCR07G223KS
R21	72026	RESISTOR 10K OHM 1/4W 10% COMP	01121	RCR07G103KS
R22	71941	RESISTOR 820 OHM 1/4W 10% COMP	01121	RCR07G821KS
R23	71973	RESISTOR 1.8K OHM 1/4W 10% COMP	01121	RCR07G182KS
R24	72054	RESISTOR 22K OHM 1/4W 10% COMP	01121	RCR07G223KS
R25	72026	RESISTOR 10K OHM 1/4W 10% COMP	01121	RCR07G103KS
R26	71941	RESISTOR 820 OHM 1/4W 10% COMP	01121	RCR07G821KS
R27	71973	RESISTOR 1.8K OHM 1/4W 10% COMP	01121	RCR07G182KS
R28	81047	RESISTOR 1 MEG 1/8W .1% MTL FLM		
R29	80930	RESISTOR 499K OHM 1/10W .1% MTL FLM		
R30	80930	RESISTOR 499K OHM 1/10W .1% MTL FLM		
R31	81047	RESISTOR 1 MEG 1/8W .1% MTL FLM		
R32	76958	POT 100K OHM 3/4W CERMET 15T PC MT	73138	79PR100K
R33	77625	RESISTOR 243K OHM 1/4W 1% MTL FLM		RN65C2433F
R34	72002	RESISTOR 4.7K OHM 1/4W 10% COMP	01121	RCR07G472KS
R35	71989	RESISTOR 3.3K OHM 1/4W 10% COMP	01121	RCR07G332KS
R36	71951	RESISTOR 1.0K OHM 1/4W 10% COMP	01121	RCR07G102KS

DIFFERENCE ASSEMBLY

REF DESIG PREFIX 10

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
R37	71993	RESISTOR 3.9K OHM 1/4W 10% COMP	01121	RCR07G392KS
R38	71977	RESISTOR 2.2K OHM 1/4W 10% COMP	01121	RCR07G222KS
R39	71977	RESISTOR 2.2K OHM 1/4W 10% COMP	01121	RCR07G222KS
R40	72138	RESISTOR 220K OHM 1/4W 10% COMP	01121	RCR07G224KS
R41	72138	RESISTOR 220K OHM 1/4W 10% COMP	01121	RCR07G224KS
R42	72138	RESISTOR 220K OHM 1/4W 10% COMP	01121	RCR07G224KS
R43	72138	RESISTOR 220K OHM 1/4W 10% COMP	01121	RCR07G224KS
R44	72077	RESISTOR 47K OHM 1/4W 10% COMP	01121	RCR07G473KS
R45	72077	RESISTOR 47K OHM 1/4W 10% COMP	01121	RCR07G473KS
R46	79462	RESISTOR 100K OHM .1W .05%	91637	MWA-8
R47	79462	RESISTOR 100K OHM .1W .05%	91637	MWA-8
R48	82141	RESISTOR 33.2K OHM RN60C/D 1% MTL FLM		RN60C3322F
R49	79462	RESISTOR 100K OHM .1W .05%	91637	MWA-8
R50	78246	RESISTOR 10.0K OHM RN60C/D 1% MTL FLM		RN60C1002F
R51	74722	RESISTOR 4.7K OHM 1/4W 5% COMP	01121	RCR07G472JS
R52	78246	RESISTOR 10.0K OHM RN60C/D 1% MTL FLM		RN60C1002F
R53	76596	POT 10K OHM 1W WW 20T PC MT	80294	3005P-1-103
R54	76598	POT 2K OHM 1W WW 20T PC MT	80294	3005P-1-202
R55	75651	RESISTOR 2.0K OHM 1/4W 5% COMP	01121	RCR07G202JS
U01	79738	IC DIFF DUAL VOLTAGE COMPARATOR	82740	RM711A
U02	78977	IC OP AMP GEN.PUR.TO-5 INT.COMP+70C 741C	80211	MC1741CG
U03	79738	IC DIFF DUAL VOLTAGE COMPARATOR	82740	RM711A
U04	78977	IC OP AMP GEN.PUR.TO-5 INT.COMP+70C 741C	80211	MC1741CG
U05	80911	IC OP AMP LO OFFSET TO-5 UNCOMP+70C 308A	12040	LM-308A
U06	76702	IC DTL QUAD 2-IN NAND GATE	80211	MC846
U07	76702	IC DTL QUAD 2-IN NAND GATE	80211	MC846
U08	80911	IC OP AMP LO OFFSET TO-5 UNCOMP+70C 308A	12040	LM-308A
U09	78977	IC OP AMP GEN.PUR.TO-5 INT.COMP+70C 741C	80211	MC1741CG

PARTS LIST ASSY POWER SUPPLY

1833 DRAWING NO 7-16 REF DESIG PREFIX A10

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
A01	96832	+ AND - 15V REGULATOR ASSY	24681	FRL10
A02	115083	5V REGULATOR ASSY		
CR01	79760	DIODE 1N1341R SIL 50V 6A	80211	1N1341R
CR02	79760	DIODE 1N1341R SIL 50V 6A	80211	1N1341R
CR03	79440	DIODE 1N3997RA SI ZEN 5.6V 5% 10W	80211	1N3997RA
F01	71220	FUSE 1 AMP SLO BLO	75915	3AG
F02	71223	FUSE 2 AMP	75915	3AG
P01	77778	CORD SET 3-WIRE #18 125V 6-FT MIN.	70903	17237-SVT
Q01	78017	TRANSSTR 2N3055 NPN SIL TO-3 CASE	13715	2N3055
Q02	78017	TRANSSTR 2N3055 NPN SIL TO-3 CASE	13715	2N3055
Q03	78017	TRANSSTR 2N3055 NPN SIL TO-3 CASE	13715	2N3055
R01	71813	RESISTOR .5 OHM 3W	24681	VAL3
S01	78160	SWITCH SLIDE DPDT LABELED 115V-220V	82389	46256LF
T01	113009	XFMR 3SEC 180V.075A 36VCT 1.2A 16.5VCT		
XA01	76584	CONNECTR 10 PIN DOUBLE READOUT	71785	251-10-30-160
XA02	76584	CONNECTR 10 PIN DOUBLE READOUT	71785	251-10-30-160
XF01	71249	FUS HLDR PNL MT FOR 3AG OR 3AB	71400	HKP
XF02	71249	FUS HLDR PNL MT FOR 3AG OR 3AB	71400	HKP

PARTS LIST ASSY +8-15V POWER SUPPLY

1833 DRAWING NO 7-17 REF DESIG PREFIX A10A1

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
CR01	78274	DIODE 1N4002 SIL 100V 1A	80211	IN4002
CR02	78274	DIODE 1N4002 SIL 100V 1A	80211	IN4002
CR03	78274	DIODE 1N4002 SIL 100V 1A	80211	IN4002
CR04	78274	DIODE 1N4002 SIL 100V 1A	80211	IN4002
CR05	71142	DIODE 1N4154 SIL 25V 150MA	80368	1N4154
CR06	71142	DIODE 1N4154 SIL 25V 150MA	80368	1N4154
C01	75221	CAPACITR 1100 MF 50V	80183	3SDU8G050HP4
C02	70498	CAPACITR 47 PF 500V SILVER MICA 5%	14655	CD15ED470J03
C03	70629	CAPACITR 6.8 MF 35V SOLID TANT POL 10%	80183	1E4D-685X9035B2
C04	75221	CAPACITR 1100 MF 50V	80183	3SDU8G050HP4
C05	70629	CAPACITR 6.8 MF 35V SOLID TANT POL 10%	80183	1E4D-685X9035B2
C06	70629	CAPACITR 6.8 MF 35V SOLID TANT POL 10%	80183	1E4D-685X9035B2
C07	70540	CAPACITR 470 PF 1KV CER DISC	71590	DD-471
C08	70501	CAPACITR 47 PF 1KV CER DISC	71590	DD-470
IC01	78719	IC VOLTAGE RGLTR 4.5 TO 30V +40V INPUT	12040	LM-305 TO-5 CASE
IC02	78720	IC VOLTAGE RGLTR -2 TO -20V -35V INPUT	12040	LM-304 TO-5 CASE
Q01	76316	TRANSSTR 2N4036 PNP SIL	79089	2N4036
Q02	76316	TRANSSTR 2N4036 PNP SIL	79089	2N4036
Q03	79439	TRANSSTR MM-4003 PNP SIL VCEO 250V	80211	MM-4003
Q04	77147	TRANSSTR 2N3947 NPN SIL	80211	2N3947
R01	71887	RESISTOR 100 OHM 1/4W 10% COMP		CB1011
R02	71836	RESISTOR 10 OHM 1/4W 10% COMP		CB1001
R03	71963	RESISTOR 1.2K OHM 3W	24681	VAL3
R04	71813	RESISTOR .5 OHM 3W	24681	VAL3
R05	79729	RESISTOR 13.0K OHM 1/10W 1% MTL FLM		RN55C1302F
R06	79728	RESISTOR 9.09K OHM 1/10W 1% MTL FLM		RN55C9091F
R07	76599	POT 500 OHM 1W WW 20T PC MT	80294	3006P-1-501
R08	78930	RESISTOR 2.21K OHM 1/10W 1% MTL FLM		RN55C2211F
R09	71957	RESISTOR 1.0K OHM 3W	24681	VAL3
R10	71813	RESISTOR .5 OHM 3W	24681	VAL3
R11	71836	RESISTOR 10 OHM 1/4W 10% COMP		CB1001
R12	71887	RESISTOR 100 OHM 1/4W 10% COMP		CB1011
R13	71938	RESISTOR 680 OHM 1/4W 10% COMP		CB6211

PARTS LIST ASSY +8-15V POWER SUPPLY

1833 DRAWING NO 7-17 REF DESIG PREFIX A10A1

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
R14	72132	RESISTOR 180K OHM 1/2W 10% COMP		EB1841
R15	71907	RESISTOR 220 OHM 1/4W 10% COMP		GB2211
R16	71938	RESISTOR 680 OHM 1/4W 10% COMP		GB6211
R17	72002	RESISTOR 4.7K OHM 1/4W 10% COMP		GB4721
R18	71966	RESISTOR 1.5K OHM 1/4W 10% COMP		GB1521
R19	71982	RESISTOR 2.7K OHM 1/4W 10% COMP		GB2721

PARTS LIST ASSY +5V REGULATOR, +250V POWER SUPPLY

1833 DRAWING NC 7-18 REF DESIG PREFIX A10A2

COMP DESIG	S-A PART NC	DESCRIPTION	FSCM	MFR PART NC
CR01	71132	DIODE 1N2484 SIL 600V 1A	84970	1N2484
CR02	71120	DIODE 1N816 SI REFERENCE STABISTOR	80368	1N816
C01	79633	CAPACITR 4000 MF 15V	80183	39D
C02	79633	CAPACITR 4000 MF 15V	80183	39D
C03	77250	CAPACITR 20 MF 350V	80183	39D206F350FL4
Q01	77148	TRANSSTR 2N3251 PNP SIL	80211	2N3251
Q02	73120	TRANSSTR 2N328A PNP SIL	01295	2N328A
R01	72023	RESISTOR 9.09K OHM 1/4W 1% DEP CAR	91637	DC-1/4
R02	77560	POT 2K OHM 1/4W COMP PC MT	01121	FR202M
R03	78904	RESISTOR 3.92K OHM 1/4W 1% MTL FLM		RN60D3921F
R04	71951	RESISTOR 1.0K OHM 1/4W 10% COMP		GB1021
R05	71836	RESISTOR 10 OHM 1/4W 10% COMP		GB1001
R06	71836	RESISTOR 10 OHM 1/4W 10% COMP		GB1001
R07	71951	RESISTOR 1.0K OHM 1/4W 10% COMP		GB1021
R08	72133	RESISTOR 180K OHM 1W 10% COMP		GB1841

PARTS LIST ASSY CHANNEL B MOTHERBOARD

1833 DRAWING NO 7-1 REF DESIG PREFIX A11

COMP DESIG	S-A PART NO	DESCRIPTION	FSCM	MFR PART NO
A01*#	115059	ASSEMBLY FILTER/BOLOMETER CURRENT		
A02#	113143	SYNCHRONOUS DEMODULATOR ASSEMBLY		
A03#	113097	REFERENCE LIMITER CIRCUIT ASSEMBLY		
A04#	113161	LIN/LOG AMPLIFIER ASSEMBLY		
A05#	113192	INTERCONNECT & 6.4MHZ OSCILLATOR ASSY		
C01	70671	CAPACITR 100 MF 25V		5C0D107G025DD7
C02	70671	CAPACITR 100 MF 25V		5C0D107G025DD7
J01	76973	CONN COAX 27 THREADED MALE TO LUG CHS MT	C266O	27-9
J02	81541	SOCKET DUAL IN LINE 16 PIN		316-AG5D-R
J03	76973	CONN COAX 27 THREADED MALE TO LUG CHS MT	C266O	27-9
R01	72014	RESISTOR 6.8K OHM 1/4W 10% COMP		GB6821
R02	71938	RESISTOR 680 OHM 1/4W 10% COMP		GB6211
R03	79452	RESISTOR 1.0K OHM .1W .01%	91637	MwA-8
R04	71907	RESISTOR 220 OHM 1/4W 10% COMP		GB2211
R05	71907	RESISTOR 220 OHM 1/4W 10% COMP		GB2211
XA01	76587	CONNECTR 15 PIN DOUBLE READOUT	71785	252-15-30-160
XA02	76587	CONNECTR 15 PIN DOUBLE READOUT	71785	252-15-30-160
XA03	76587	CONNECTR 15 PIN DOUBLE READOUT	71785	252-15-30-160
XA04	76587	CONNECTR 15 PIN DOUBLE READOUT	71785	252-15-30-160
XA05	78279	CONNECTR 22 PIN DOUBLE READOUT	71785	252-22-30-160
XA06	76587	CONNECTR 15 PIN DOUBLE READOUT	71785	252-15-30-160

*SEE PARAGRAPH 6.4

#SEE ASSEMBLY A1

MANUFACTURERS' CODE LIST

FSCM	Manufacturer
00348	Microtran Co., Inc., Valley Stream, N.Y
01121	Allen-Bradley Co., Milwaukee, Wisc.
01295	Texas Instruments Inc., Dallas, Texas
01686	RCL Electronics Inc., Manchester N.H.
02335	Fairchild Controls, Hicksville, N.Y.
02660	Amphenol Corp., Broadview, Ill.
05397	Kemet Div-Union Carbide, Cleveland, Ohio
09021	Airco Speer Elec Components, Dubois, Pa.
10110	Scientific-Atlanta Inc., Atlanta, Ga.
12040	National Semiconductor Corp., Danbury, Conn.
13715	Fairchild Semiconductor Corp., San Rafael, Calif.
14655	Cornell-Dubilier Elec Corp., S. Plainfield, N.J.
18324	Signetics Corp., Sunnyvale, Calif.
24355	Analog Devices, Cambridge, Mass.
24446	General Electric Co., Schenectady, N.Y.
24681	Memcor Inc., Components Div., Huntington, Ind.
27318	Stewart-Warner Microcircuits, Sunnyvale, Calif.
70903	Belden Manufacturing Co., Chicago, Ill.
71279	Cambion-Div Cambridge Thermnic, Cambridge, Mass.
71400	Bussman Manufacturing, St. Louis, Mo.
71590	Centralab, Milwaukee, Wisc.
71785	Cinch Manufacturing Co., Chicago, Ill.
72982	Erie Resistor Corp., Erie, Pa.
73138	Helipot-Div Beckman Instr., Fullerton, Calif.
74970	Johnson E.F. Co., Waseca, Minn.
75915	Littelfuse Inc., Des Plaines, Ill.
76493	Miller J.W. Co., Los Angeles, Calif.
79089	Radio Corp. of America, Harrison, N.J.
80183	Sprague Pdts. Co., N. Adams, Mass.
80211	Motorola Inc., Chicago. Ill.
80294	Bourns Laboratories Inc., Riverside, Calif.
80368	Sylvania Electric Pdts. Inc., New York, N.Y.
81312	Winchester Electronics Inc., Norwalk, Conn.
82389	Switchcraft Inc., Chicago, Ill.
82740	Raybestos Manhattan Div., Manheim, Pa.
83594	Burroughs Corporation, Plainfield, N.J.
84171	Arco Electronics Inc., New York, N.Y.
84411	TRW Capacitor Div/Good-All/, Ogallala, Nebr.
84970	Sarkes Tarzian Inc., Bloominghton, Ind.
91637	Dale Products Inc., Columbus, Nebr.
95146	Alco Electronics Mfg. Co., Lawrence, Mass.

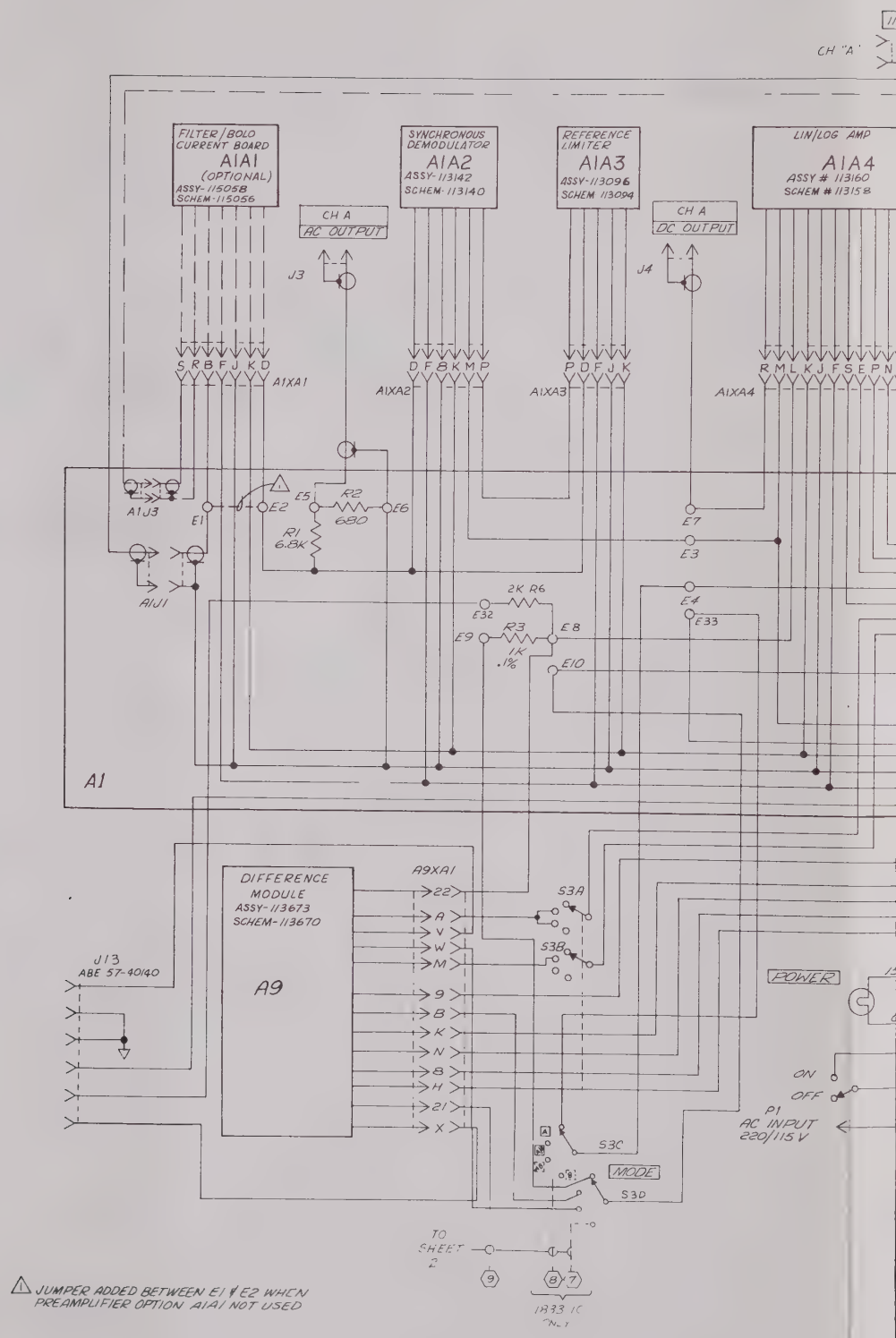
PARTS LIST ABBREVIATIONS

Abbreviation	Word
A	Ampere
AC	Alternating current
ACT	Action, acting
AFC	Automatic frequency control
AGC	Automatic gain control
AMP, AMPL	Amplifier
ANGL	Angle
APC	Automatic phase control
ASSY	Assembly
BCD	Binary-coded-decimal
CAP	Capacitance, capacitor
CAR	Carbon
CBL	Cable
CCW	Counterclockwise
CDX	Control differential transformer
CER	Ceramic
CHS	Chassis
COAX	Coaxial
COMP	Component, composition
COND	Conductor
CONN	Connector
CONT	Contact(s)
CPS	See Hertz
CRT	Cathode-ray tube
CT	Control transformer, center-tapped
CTR	Center
CW	Continuous-wave, counterclockwise
ELECT	Electrolytic, electric(al), electron(ic)
ENCAP	Encapsulated
FEM	Female
FET	Field-effect transistor
FLM	Film
FTHRU	Feedthrough
FUS	Fuse(d)
GER	Germanium
GHZ	Gigahertz
GND	Ground
H, HY	Henry
HD	Head
HEX	Six-sided
HLDR	Holder
()-IN	()-Input(s)
IC, INT CKT	Integrated circuit
IF	Intermediate frequency
IN	Input
INC	Incandenscent
INTL	Internal
JUNC	Junction
K	Kilo
LATCH	Latch(ing)
LCK	Lock, locking
M	Milli
MA	Milliampere
MAX	Maximum
MDM	Medium
MEG	Million (ohms)
MET	Metal
MF	Microfarad
MHZ	Megahertz
MIN	Minimum
MOD	Model, modular
MOLD	Molded
MOM	Momentary
MOS	Metal-oxide semi-conductor
MOT	Motor
MT, MTG	Mount, mounting
MTL	See MET
MW	Milliwatt
MYL	Mylar

PARTS LIST ABBREVIATIONS

Abbreviation	Word
NC	Normally closed
NI	Nickel
NO	Normally open
NP	Nonpolarized
NSH	Non-shorting
OP	Operating, operational
OSC	Oscillate(ing)(or) oscilloscope
P	Pico
PAP	Paper
PC	Printed circuit
PCARB	Polycarbonate
PF	Picofarad
PIV	Peak inverse voltage
PL	Plated
PNL	Panel
POL	Polar(ized)
POS	Position
POT	Potentiometer
PRI	Primary
PROT	Protect(or)(ion)
PS	Polystyrene
PUSHB	Pushbutton
PWR	Power
RCVG	Receiving
RCVR	Receiver
RECEP	Receptacle
RECT	Rectifier, rectangular
REG	Regulate(d)(ing)(or)
RES	Resist(ance)(or)
RF	Radio Frequency
RND	Round
ROT	Rotary
RT	Right
SB	Slow-acting, slow-blow
SCR	Silicon-controlled rectifier
SCS	Silicon-controlled switch
SEC	Second(ary)(s)
SEL	Select(ed)(or)
SEP	Separate
SH	Shorting
SHFT	Shaft
SHLD	Shield(ed)(ing)
SI	See SIL
SIG	Signal
SIL	Silicon
SPDT	Single-pole, double-throw
SPST	Single-pole, single-throw
SQ	Square
SUBMIN	Subminiature
SUP	Supply, suppressor
SW	Switch
T	Turn
TACH	Tachometer
TANT	Tanalum
TC	Temperature-compensat(ion)(e
TERM	Terminal(s)
TNL	Tunnel
TOG	Toggle
TTL	Transistor-transistor logic
U	Micro
UA	Micro ampere
UH	Microhenry
UHF	Ultra high frequency
UFT	Unijunction transistor
V	Volt(s)(age)
VAL	Value(s)
VAR	Variable
W	Watt
W/	With
WO/	Without
WW	Wirewound
XFMR	Transformer
XTAL	Crystal
XTR	Transmitter
ZEN	Zener

CHAPTER 7
DIAGRAMS



⚠ JUMPER ADDED BETWEEN E1 & E2 WHEN PREAMPLIFIER OPTION A1A1 NOT USED

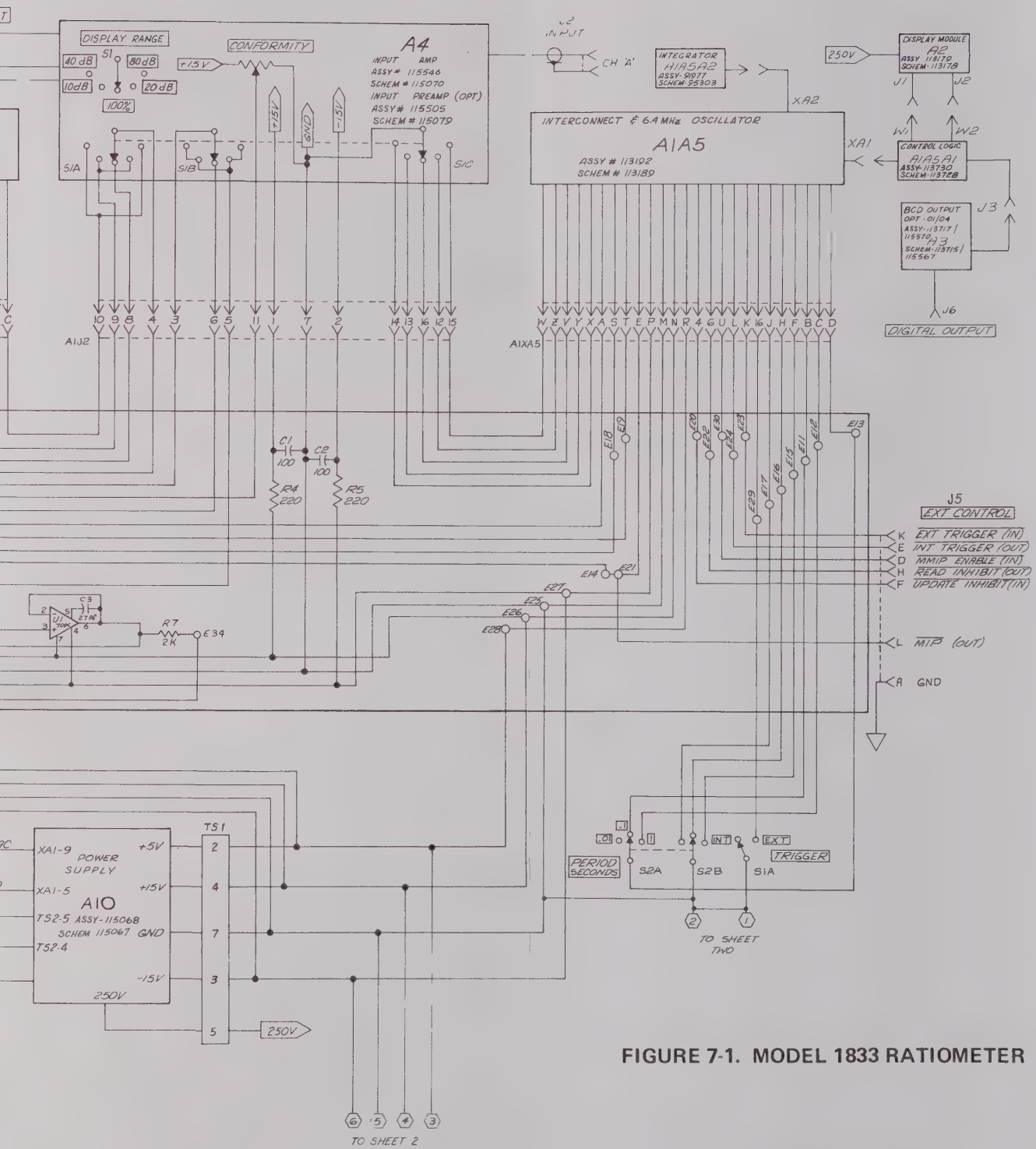


FIGURE 7-1. MODEL 1833 RATIOMETER

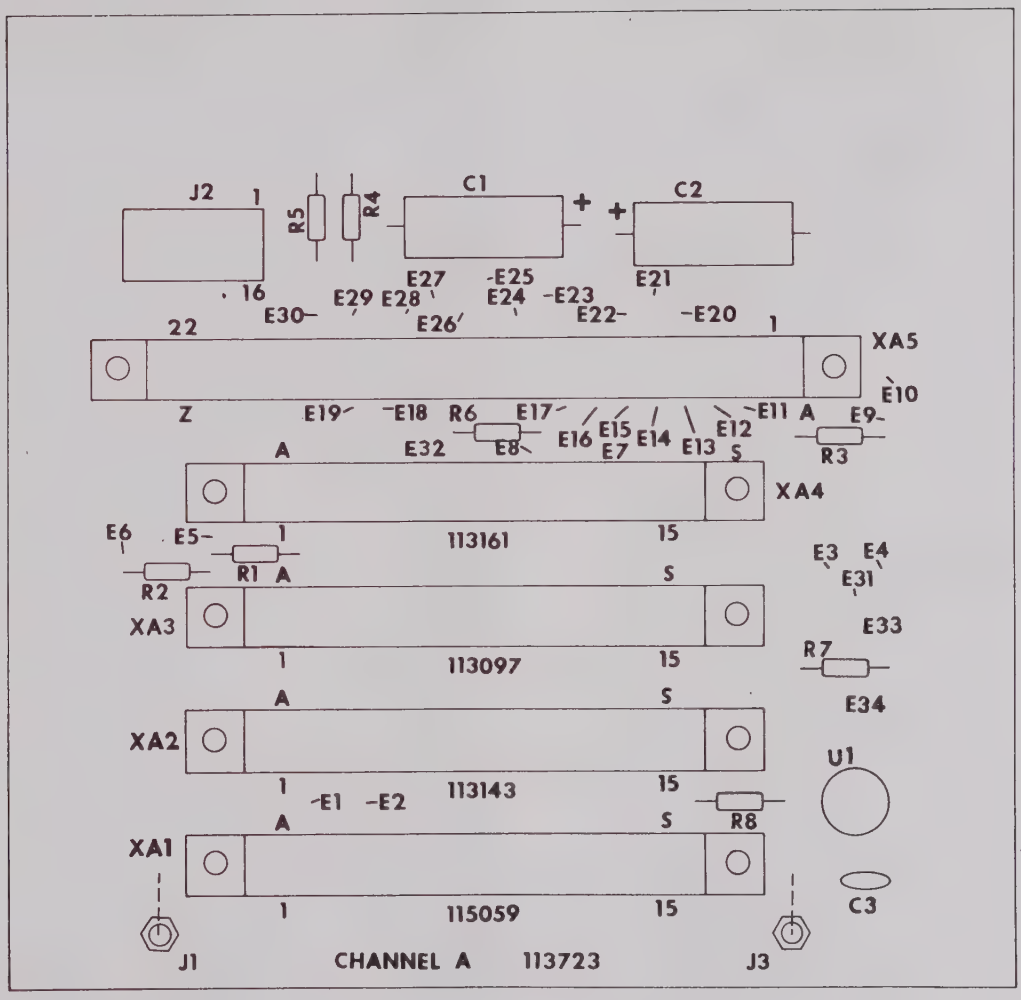
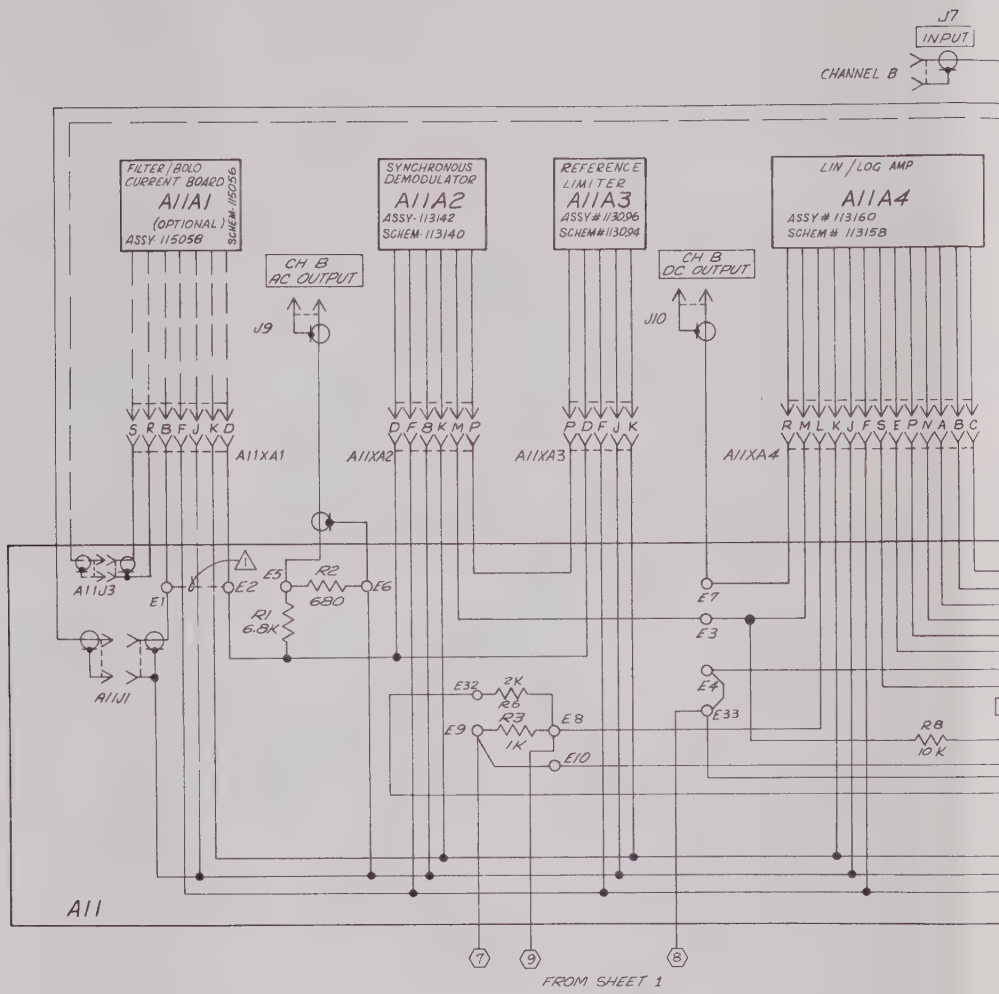


Figure 7-2. Mother Board Assembly
A1



⚠ JUMPER ADDED BETWEEN E1 & E2 WHEN PREAMPLIFIER OPTION A11A1 NOT USED

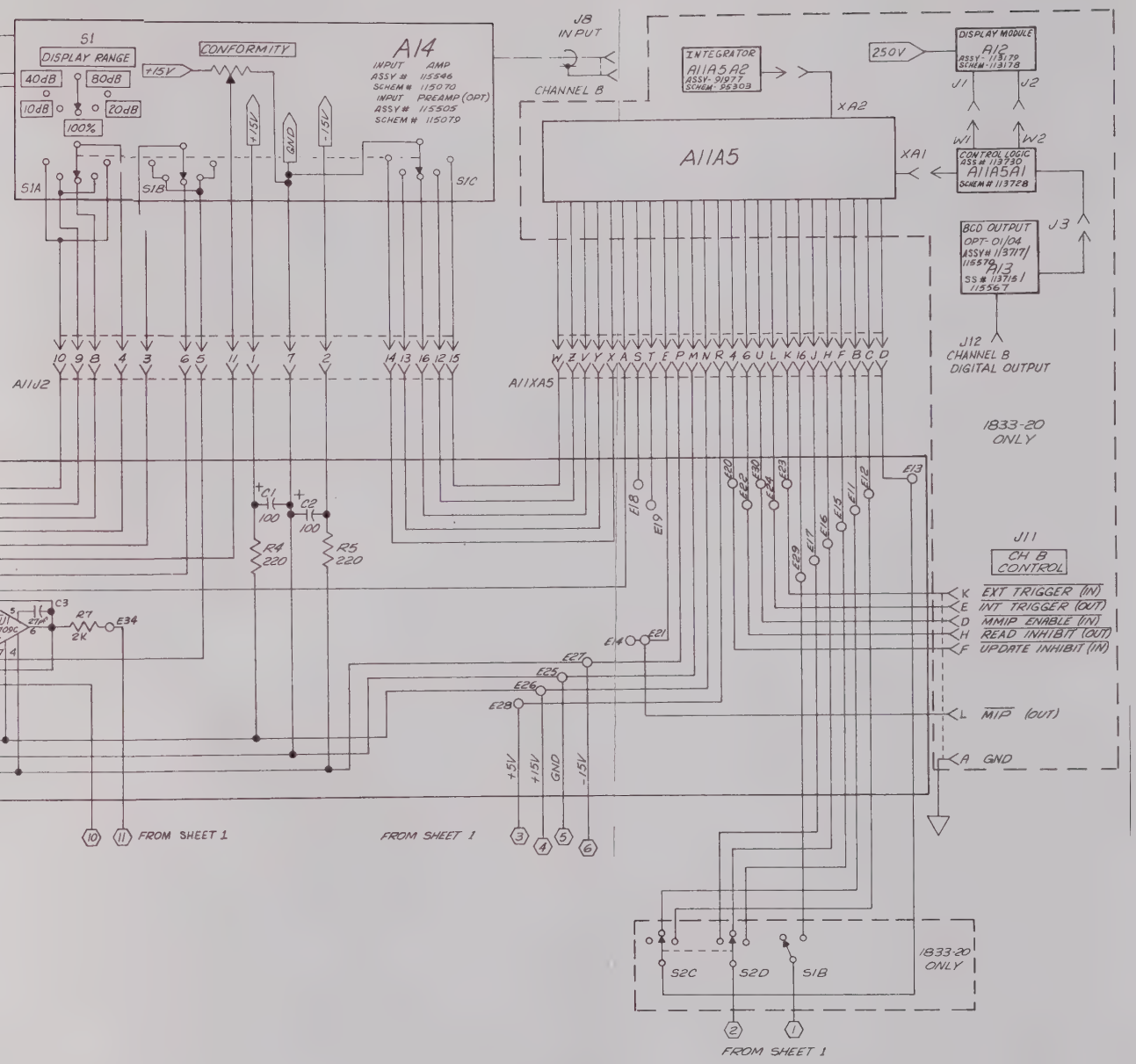


Figure 7-3. MODEL 1833A RATIOMETER

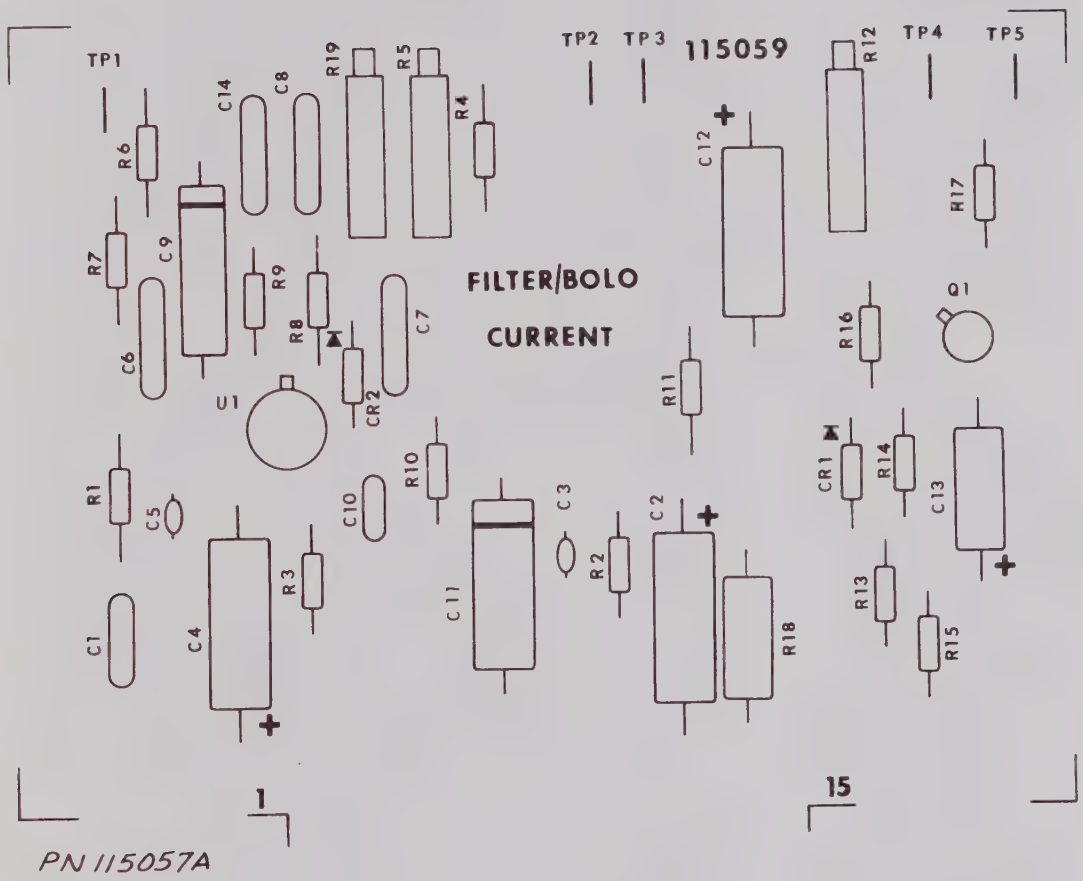
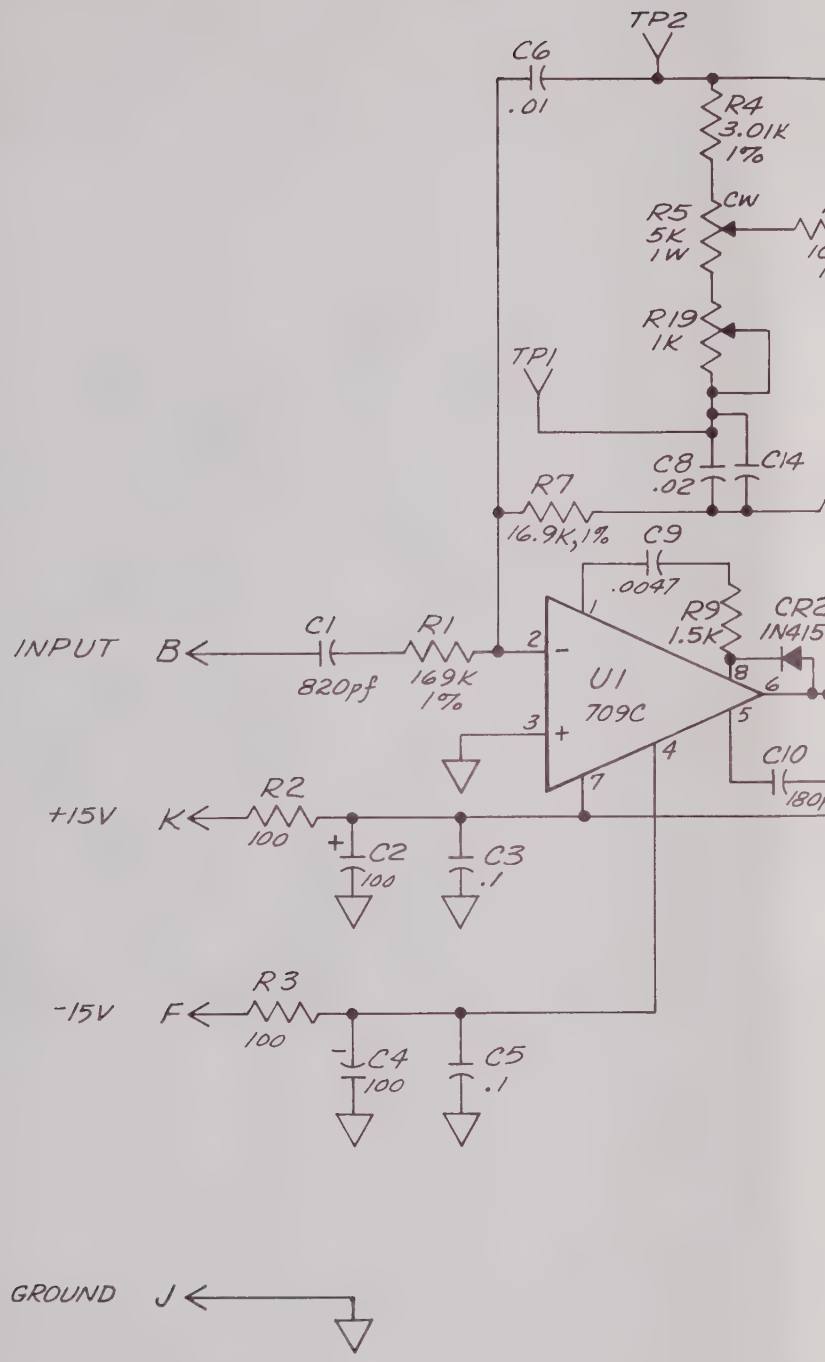


Figure 7-4. Filter / Bolometer Current

A1A1

115058A


TP2
C6
.01
R4
3.01K
1%
CW
R5
5K
1W
R19
1K
TP1
C8
.02
C14
R7
16.9K,1%
C9
.0047
R9
1.5K
CR2
IN415
INPUT
B
C1
820pf
R1
169K
1%
U1
709C
+15V
K
R2
100
C2
100
C3
.1
C10
-15V
F
R3
100
C4
100
C5
.1
GROUND
J

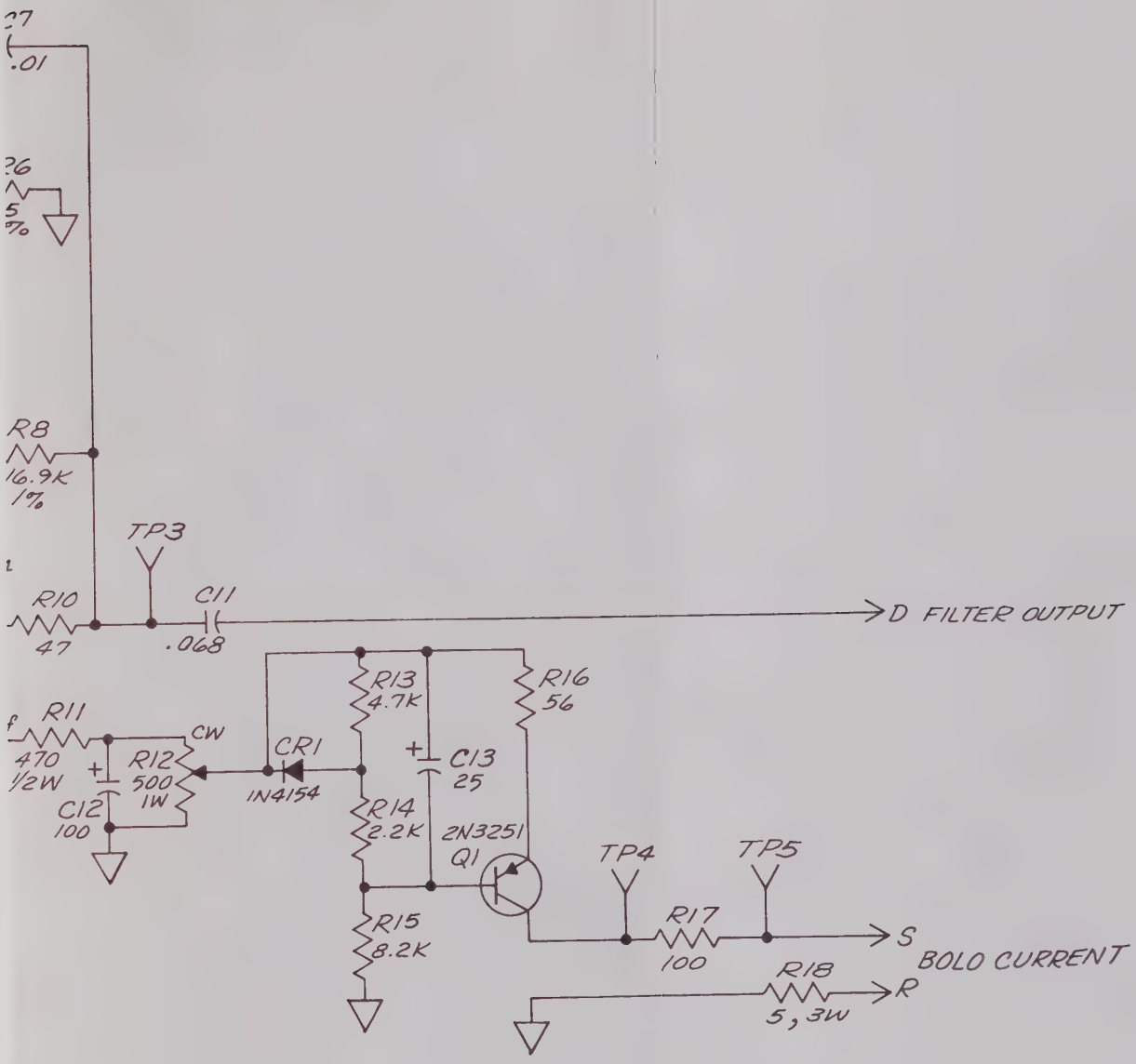
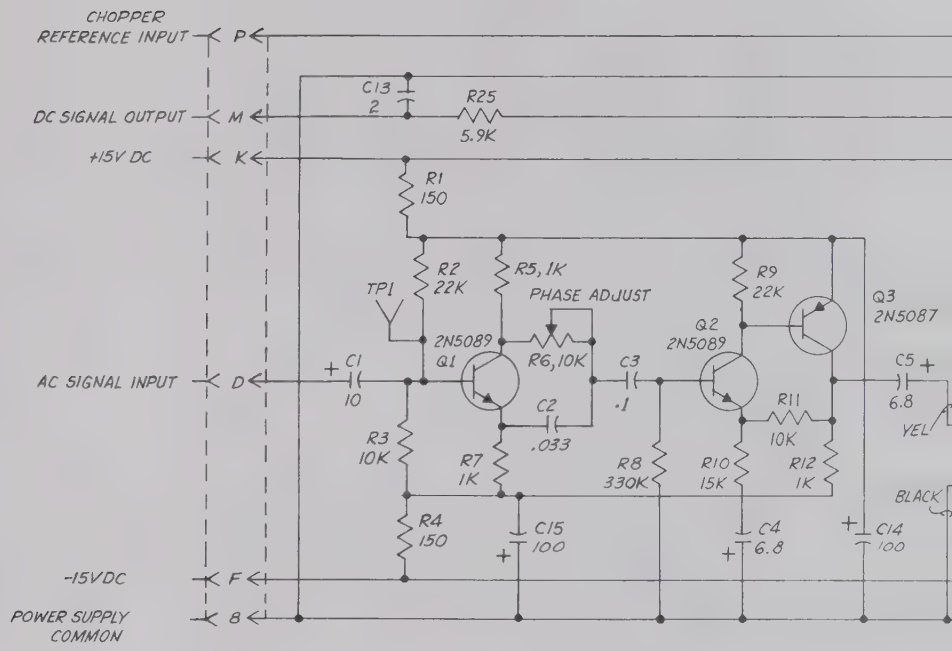


Figure 7-5. Filter / Bolometer Current

A1A1


CHOPPER
REFERENCE INPUT
P
DC SIGNAL OUTPUT
M
+15V DC
K
AC SIGNAL INPUT
D
-15VDC
F
POWER SUPPLY
COMMON
B
C13
2
R25
5.9K
R1
150
R2
22K
R5, 1K
PHASE ADJUST
TP1
2N5089
Q1
R6, 10K
C1
10
C3
.1
C2
.033
R3
10K
R7
1K
R4
150
C15
100
R9
22K
Q2
2N5089
Q3
2N5087
R11
10K
R8
330K
R10
15K
R12
1K
C4
6.8
C14
100
C5
6.8
YEL
BLACK

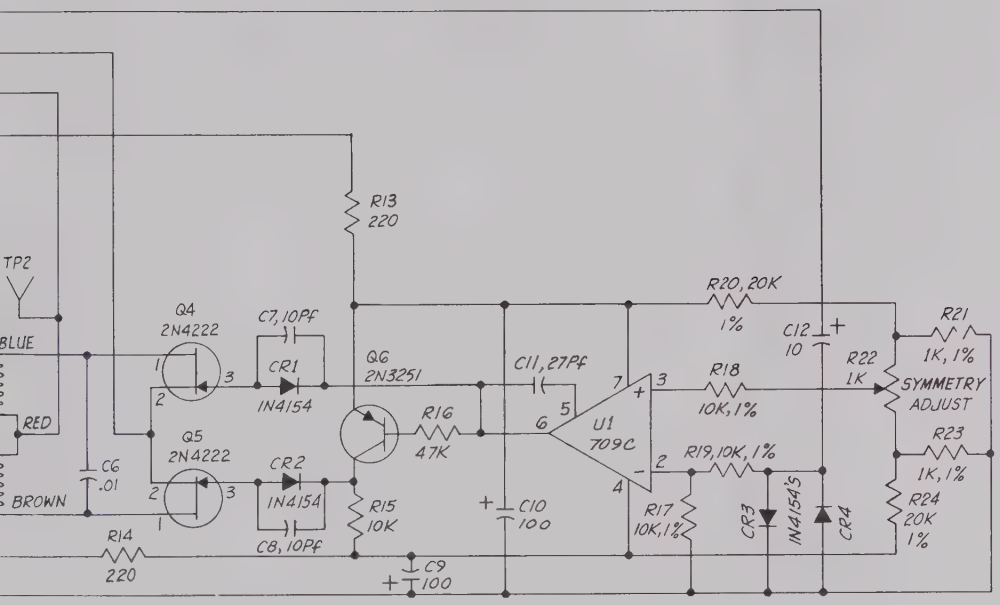


Figure 7-7. Synchronous Demodulator

A1A2

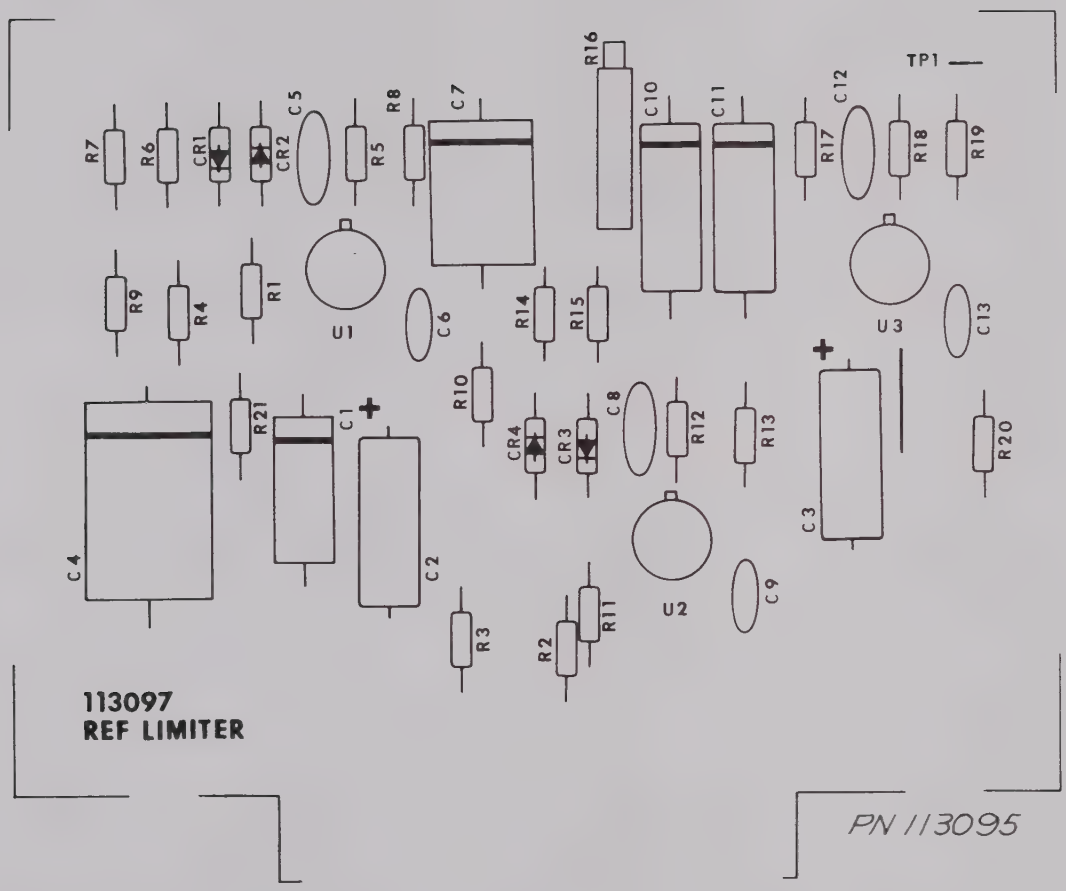
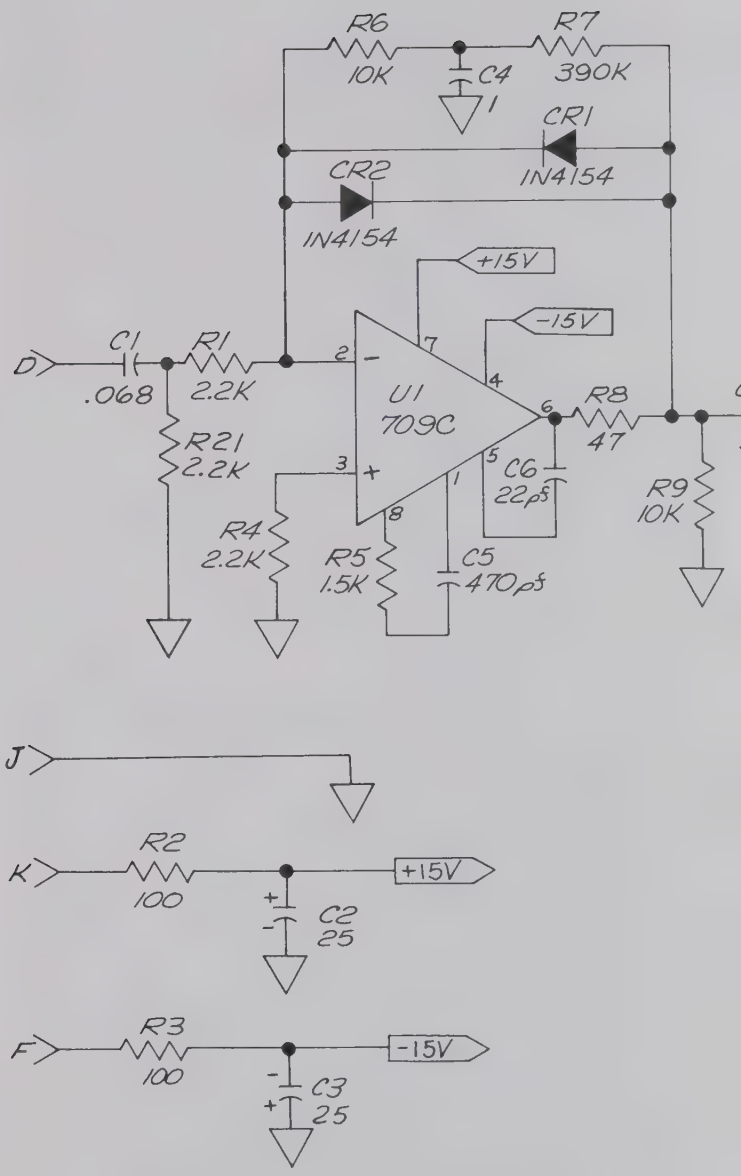


Figure 7-8. Reference Limiter Assembly

A1A3


R6
10K
C4
1
R7
390K
CR1
IN4154
CR2
IN4154
+15V
-15V
D
C1
.068
R1
2.2K
R21
2.2K
U1
709C
R8
47
C6
22pf
R9
10K
R4
2.2K
R5
1.5K
C5
470pf
J
K
R2
100
+15V
C2
25
F
R3
100
-15V
C3
25

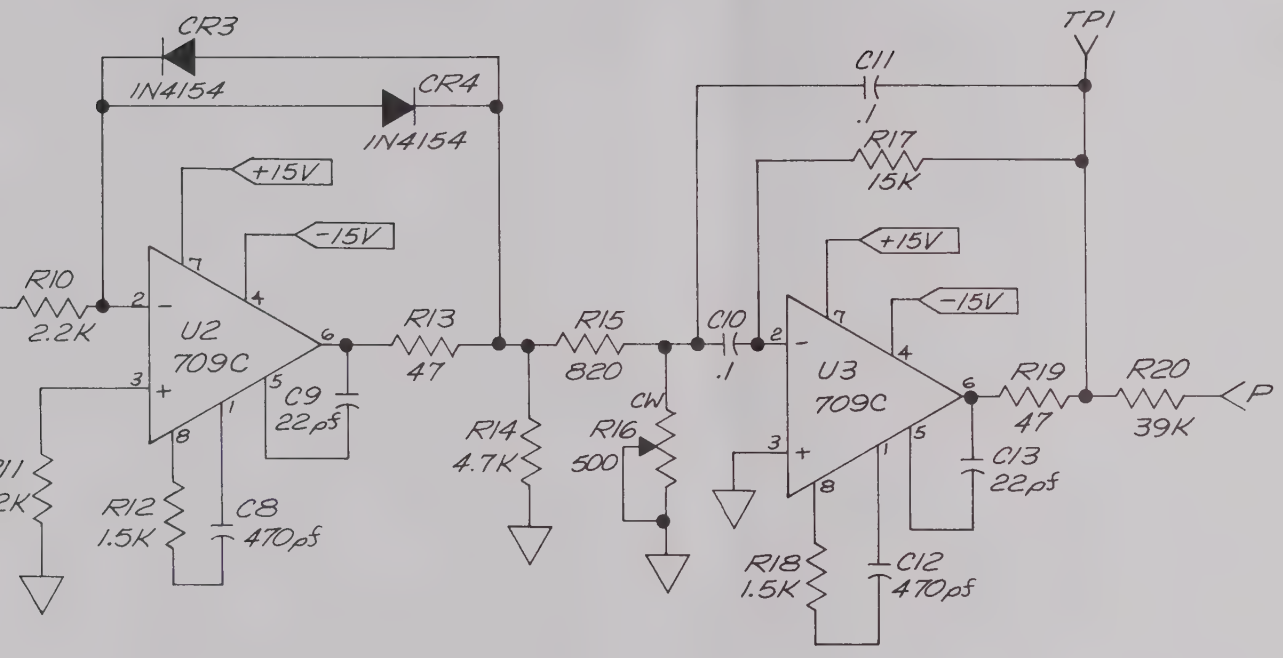


Figure 7-9. Reference Limiter

A1A3

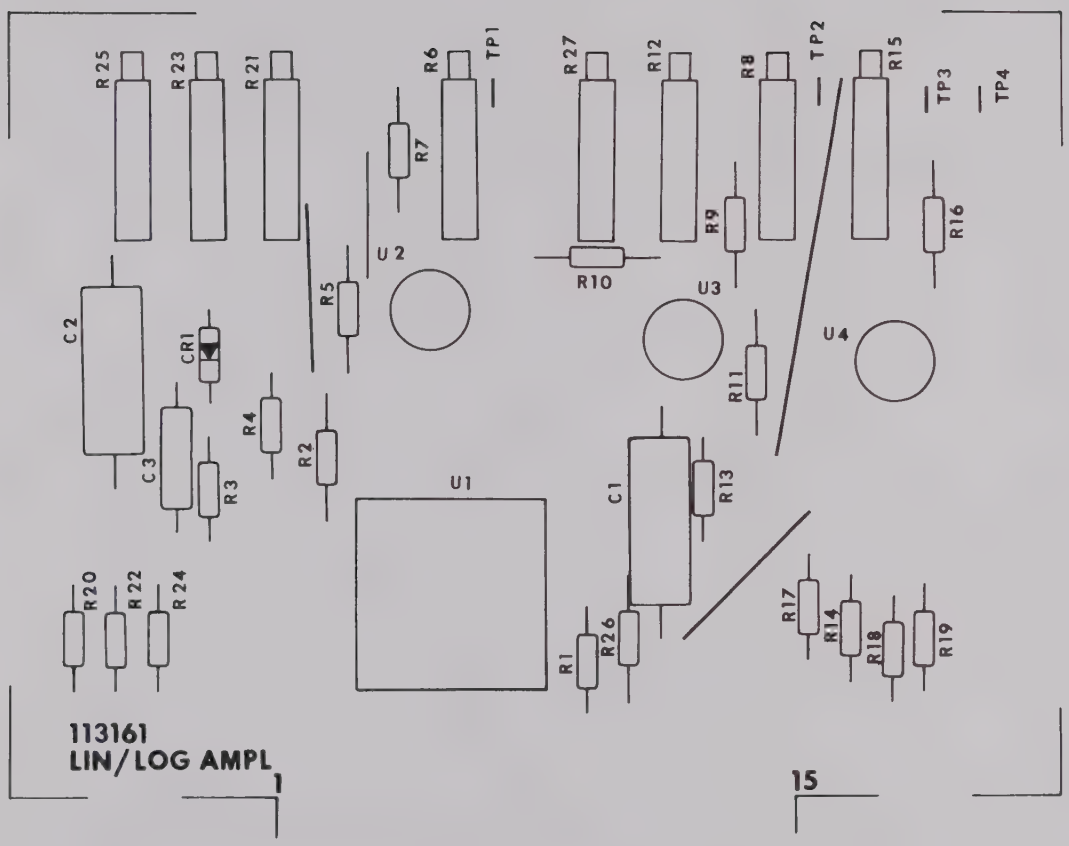
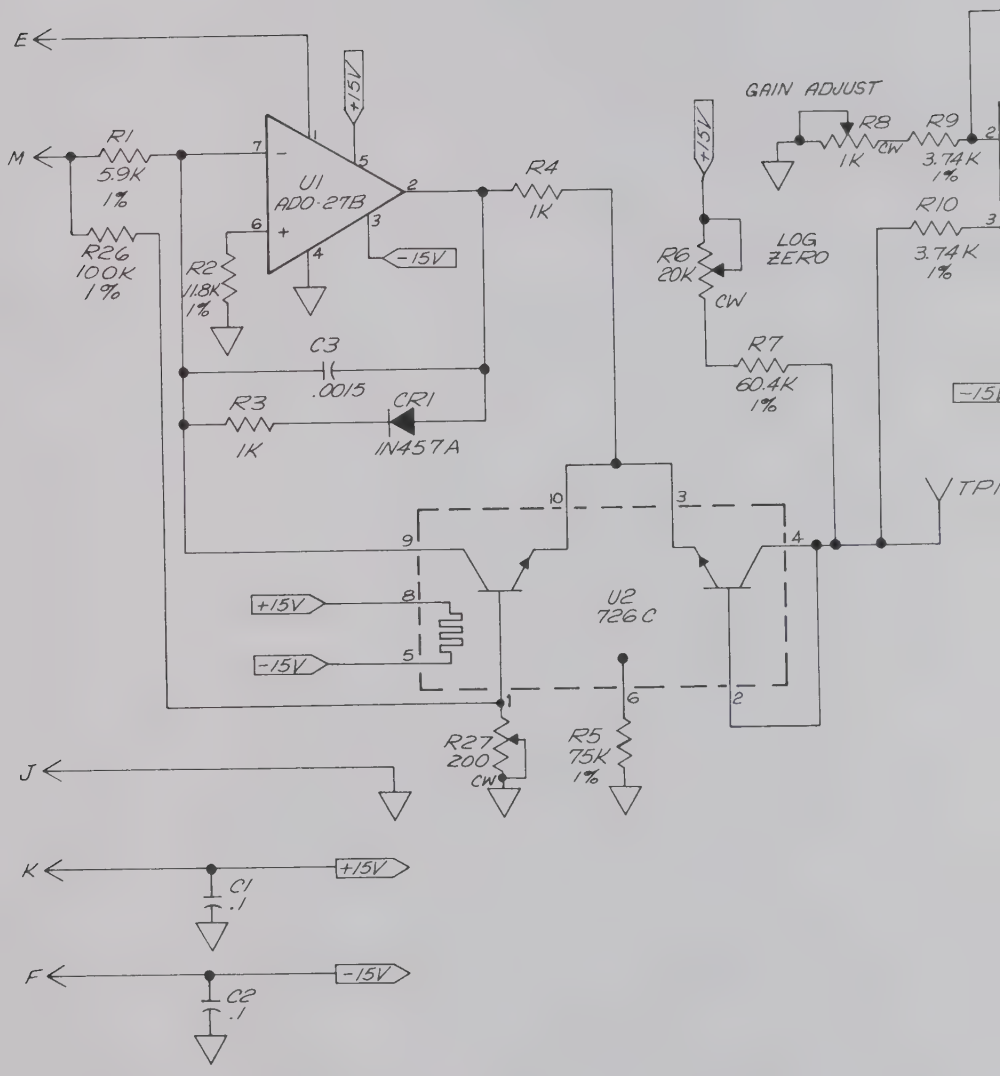


Figure 7-10. Lin/Log Amplifier Assemb

A1A4

113160


E
M
R1
5.9K
1%
R26
100K
1%
U1
ADO-27B
+15V
-15V
R2
11.8K
1%
C3
.0015
R3
1K
CR1
IN457A
R4
1K
GAIN ADJUST
R8
1K
CW
R9
3.74K
1%
R10
3.74K
1%
R6
20K
CW
LOG
ZERO
R7
60.4K
1%
U2
726C
R27
200
CW
R5
75K
1%
J
K
C1
.1
F
C2
.1

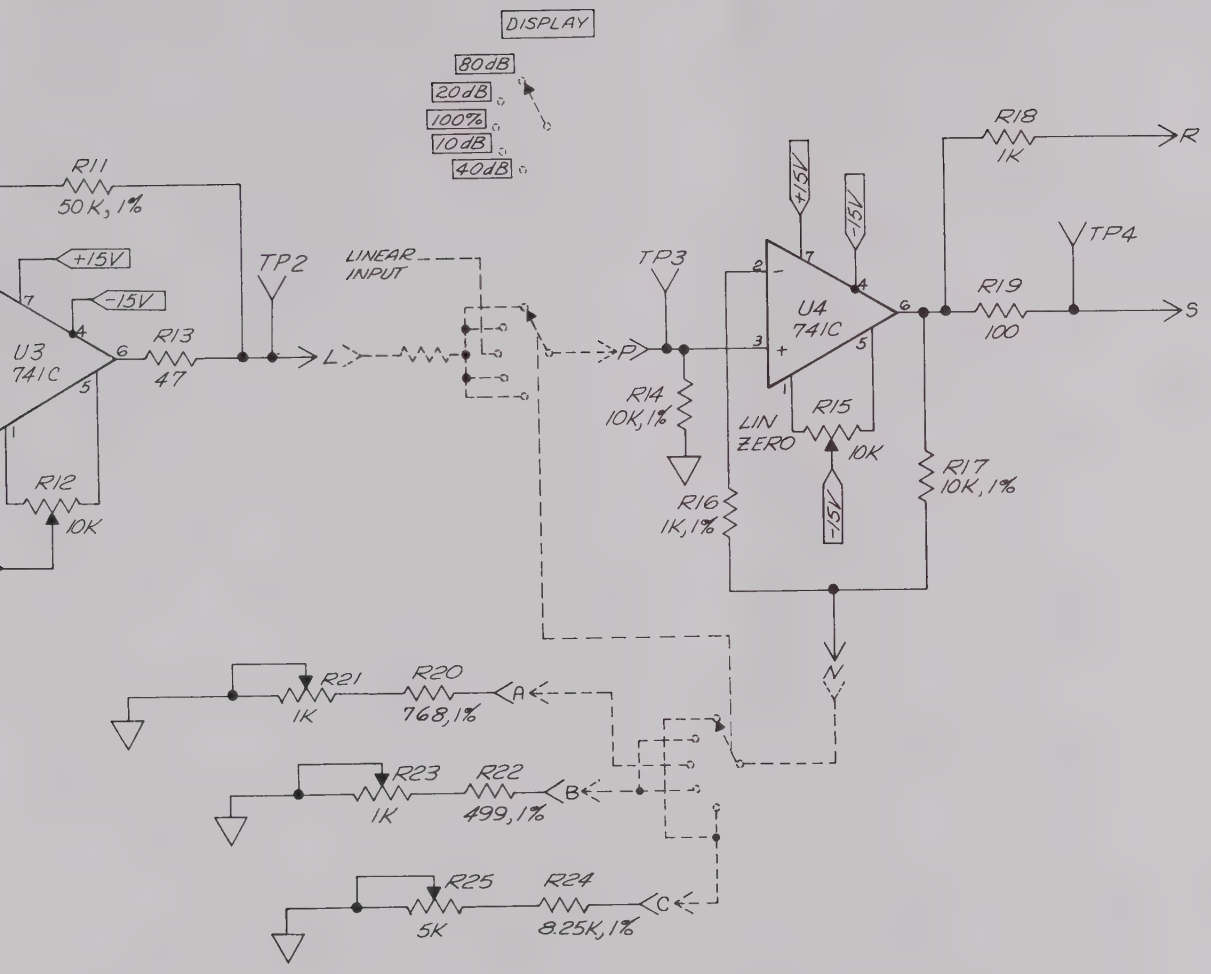


Figure 7-11. Lin/Log Amplifier

A1A4

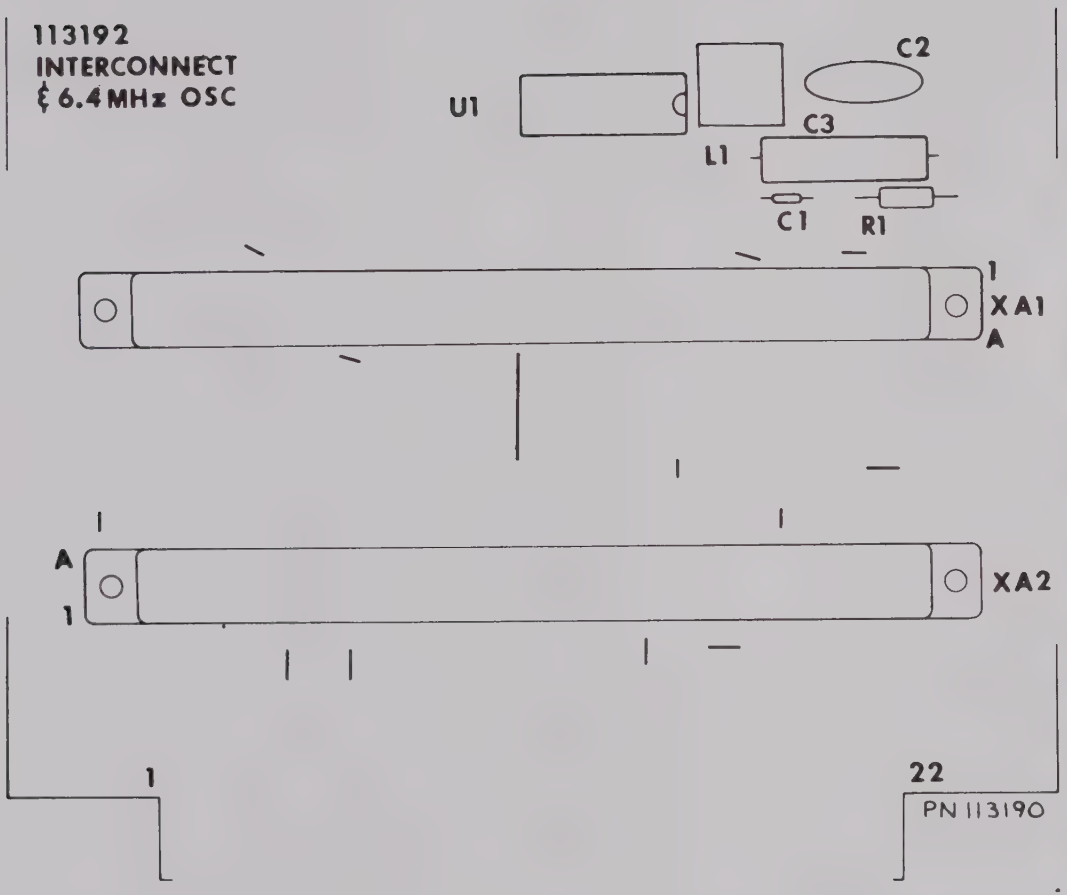
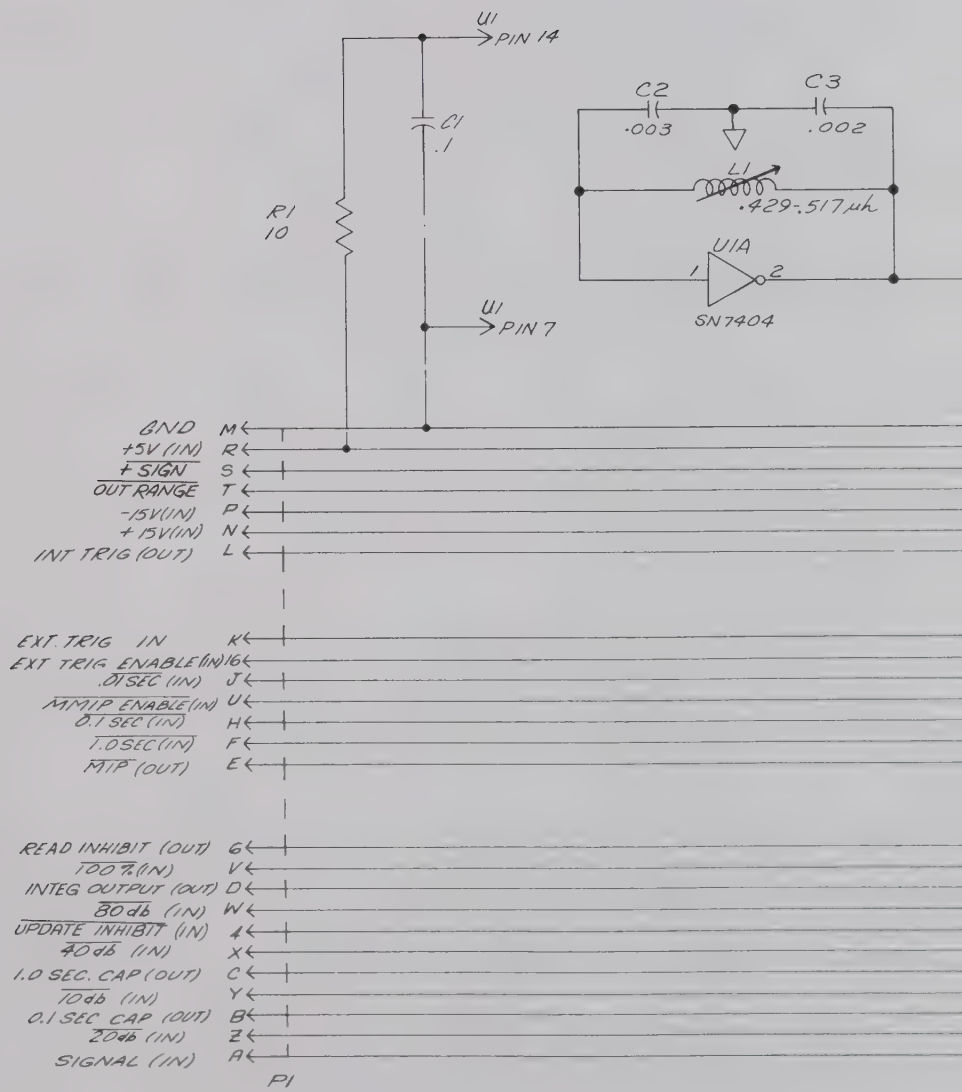


Figure 7-12. Interconnect & 6.4 MHz Oscillator Assembly A1A5


U1
PIN 14
C1
.1
R1
10
U1
PIN 7
C2
.003
C3
.002
L1
.429-.517 μh
U1A
SN7404
GND M
+5V (IN) R
+ SIGN S
OUT RANGE T
-15V(IN) P
+15V(IN) N
INT TRIG (OUT) L
EXT. TRIG IN K
EXT TRIG. ENABLE(IN) 16
.01 SEC (IN) J
M.T.I.P. ENABLE(IN) U
0.1 SEC (IN) H
1.0 SEC (IN) F
M.T.P. (OUT) E
READ INHIBIT (OUT) G
100 % (IN) V
INTEG OUTPUT (OUT) D
80 db (IN) W
UPDATE INHIBIT (IN) 4
40 db (IN) X
1.0 SEC. CAP (OUT) C
10 db (IN) Y
0.1 SEC. CAP (OUT) B
20 db (IN) Z
SIGNAL (IN) A
P1

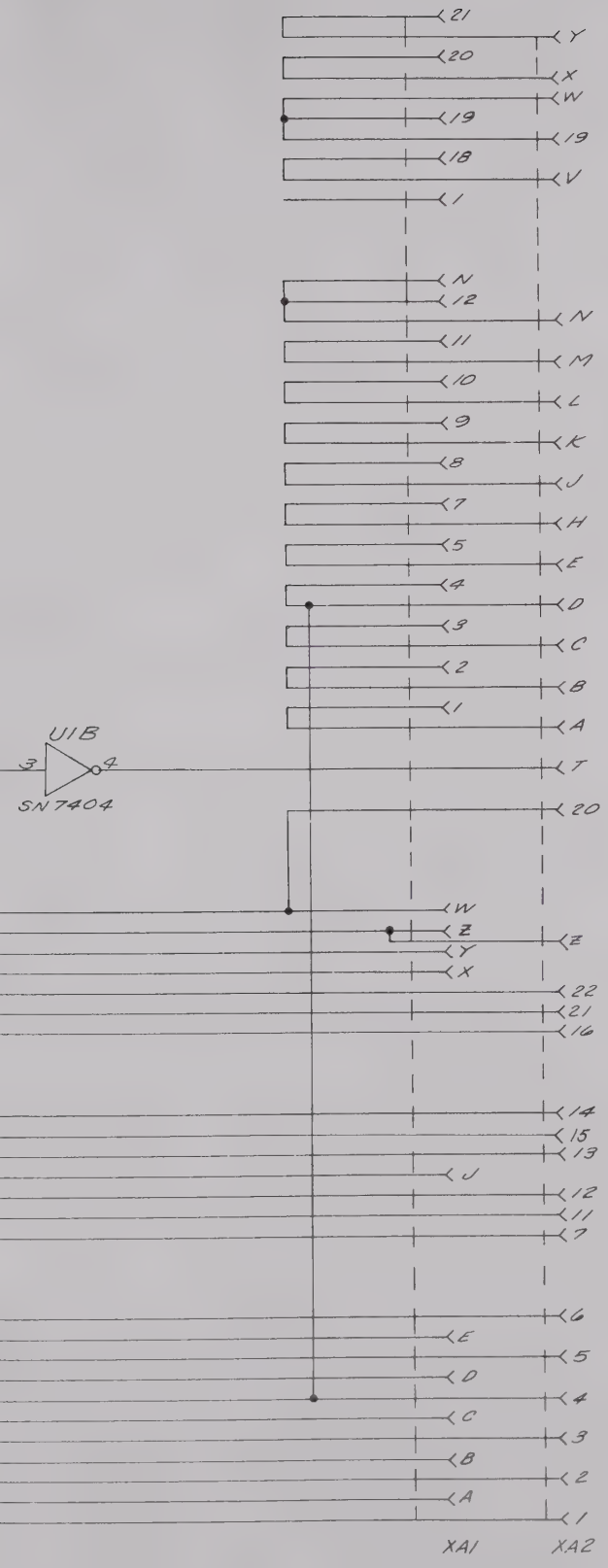
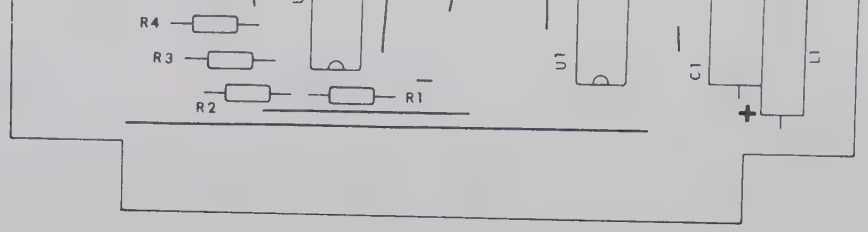


Figure 7-13. Interconnect & 6.4 MHz Oscillator

A1A5


R4
R3
R2
R1
U1
C1
L1
+

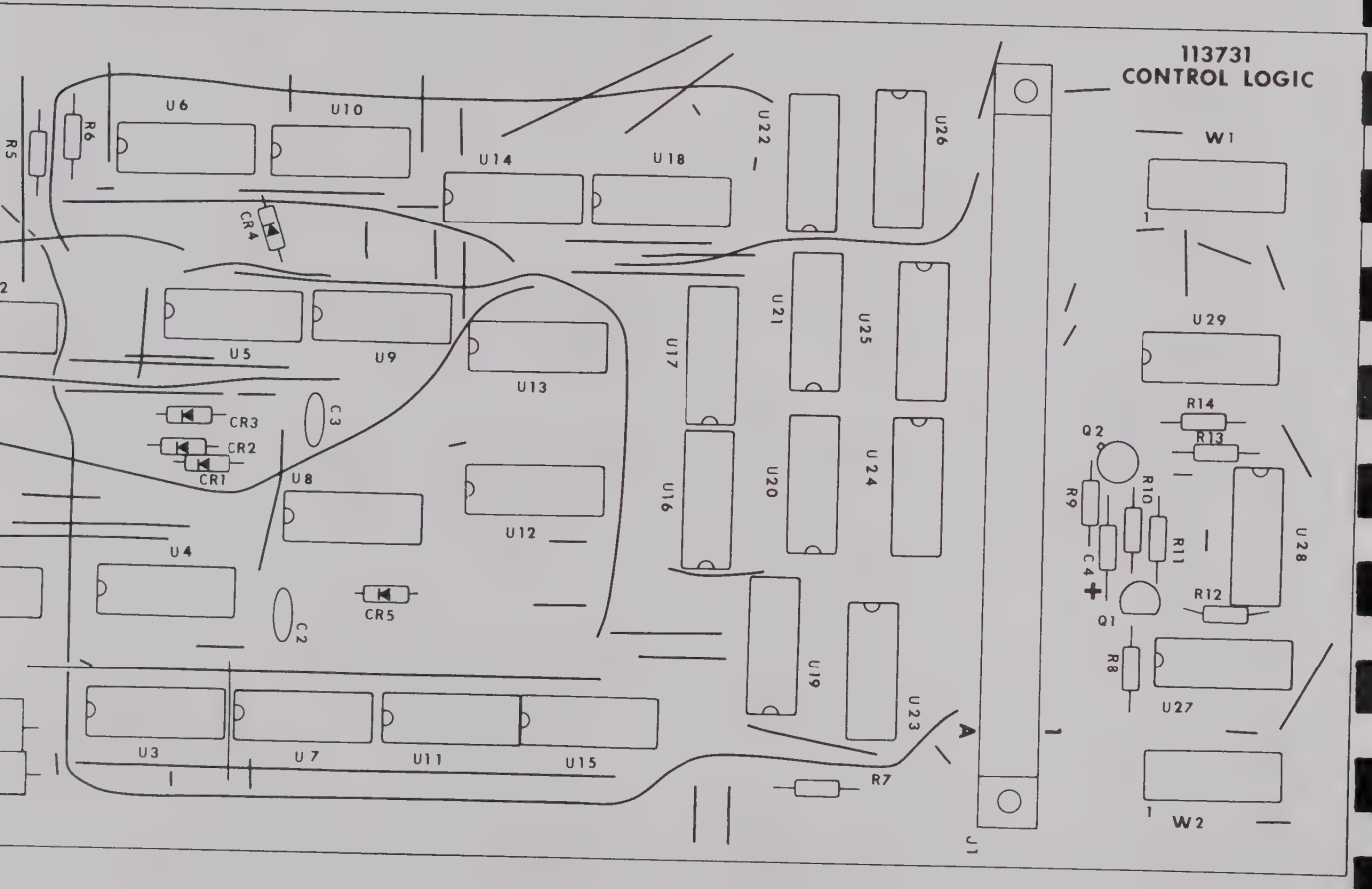
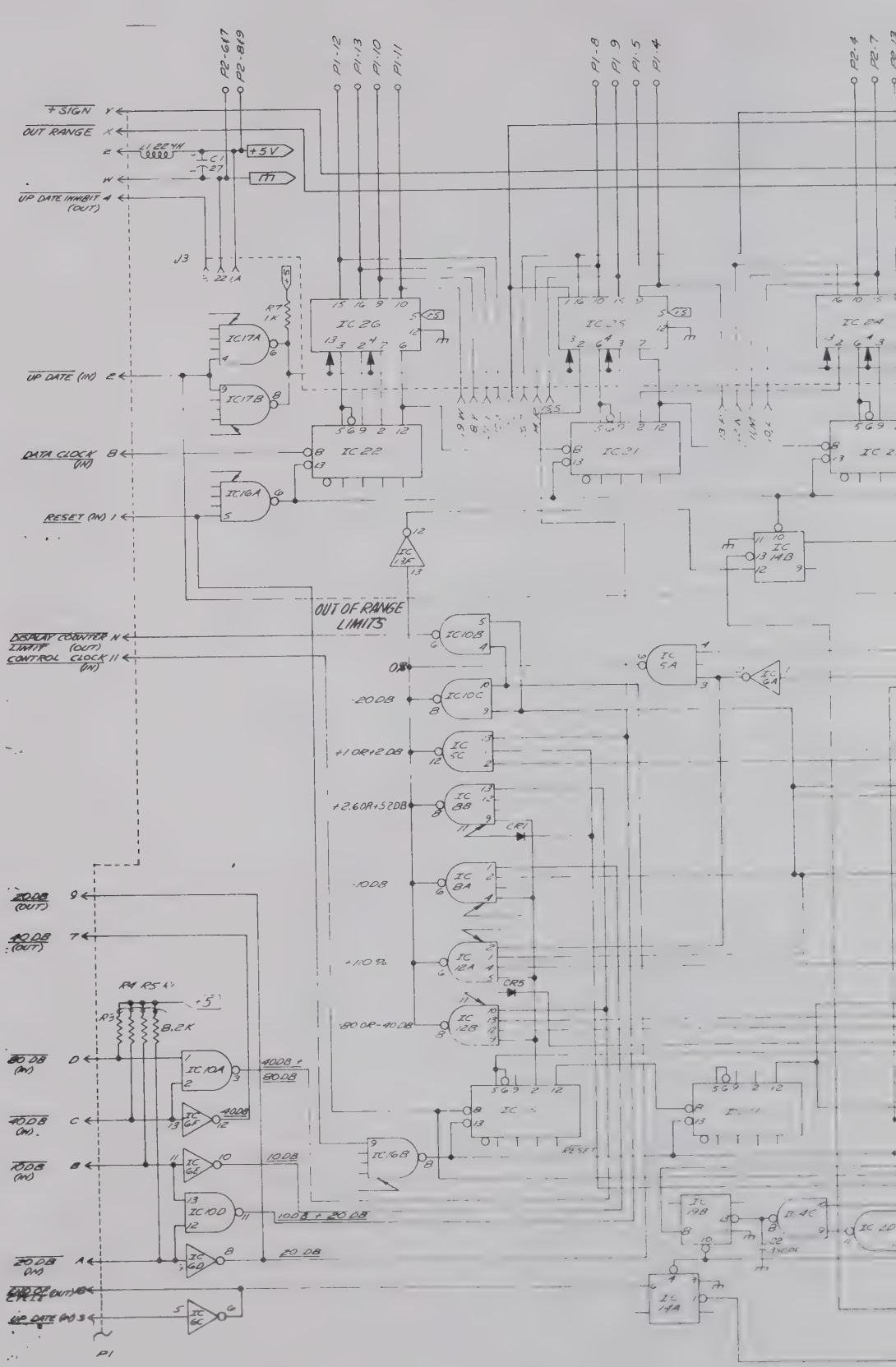


Figure 7-14. Control Logic Assembly A1A5A1


+SIGN
OUT RANGE
UP DATE INHIBIT (OUT)
UP DATE (IN)
DATA CLOCK (IN)
RESET (IN)
DISPLAY COUNTER LIMIT (OUT)
CONTROL CLOCK (IN)
OUT OF RANGE LIMITS
0dB
-20DB
+10R+12DB
+26DR+32DB
-10DB
+1.0 DB
-80 OR -40 DB
20DB (OUT)
40DB (OUT)
80 DB (IN)
40DB (IN)
10DB (IN)
20DB (IN)
+5V
IC 26
IC 25
IC 24
IC 23
IC 22
IC 21
IC 17A
IC 17B
IC 16A
IC 16B
IC 10A
IC 10B
IC 10C
IC 10D
P1
P2-6&7
P2-8&9
P1-12
P1-13
P1-10
P1-11
P1-8
P1-9
P1-5
P1-4
P2-4
P2-7

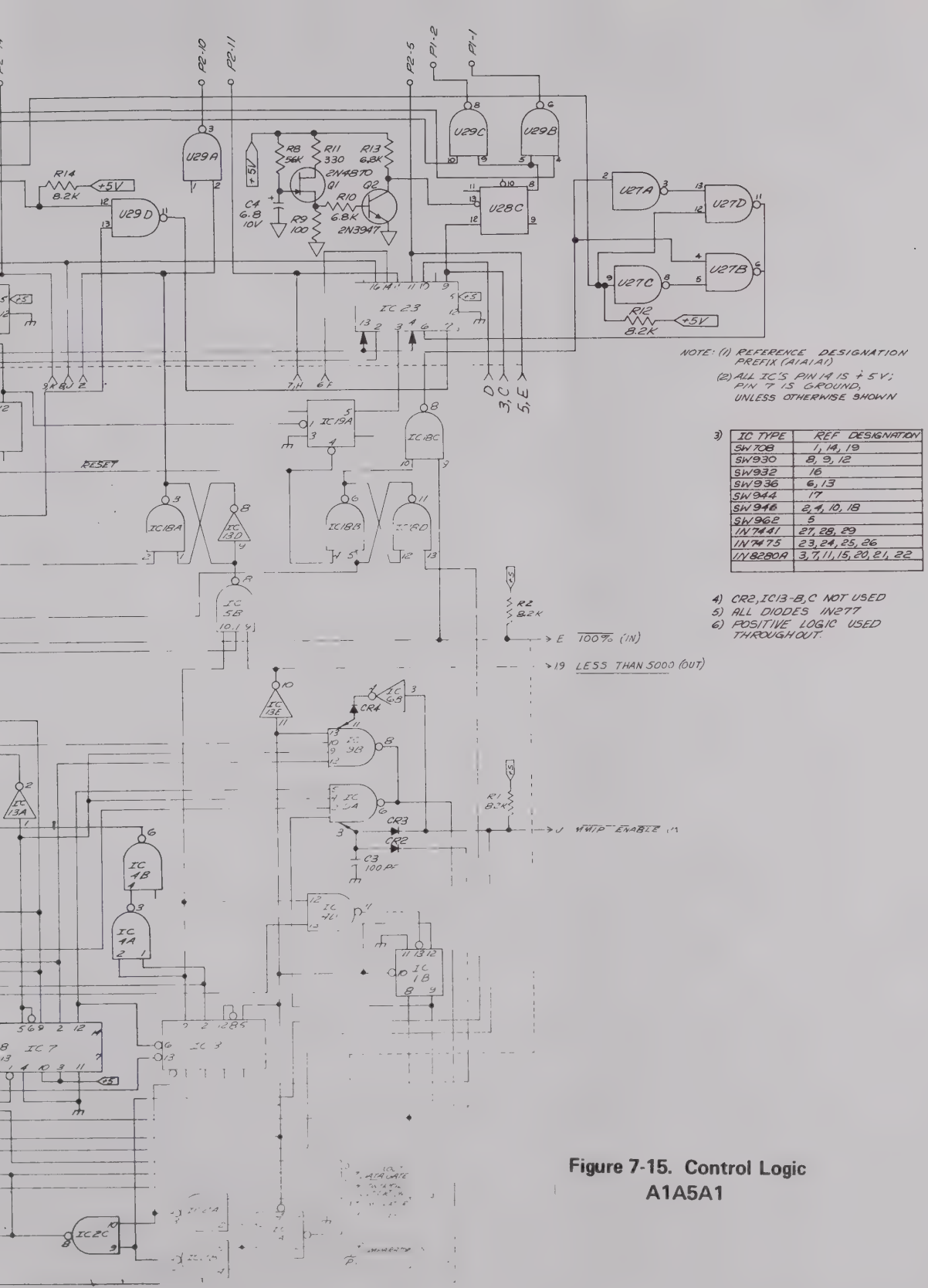


Figure 7-15. Control Logic A1A5A1

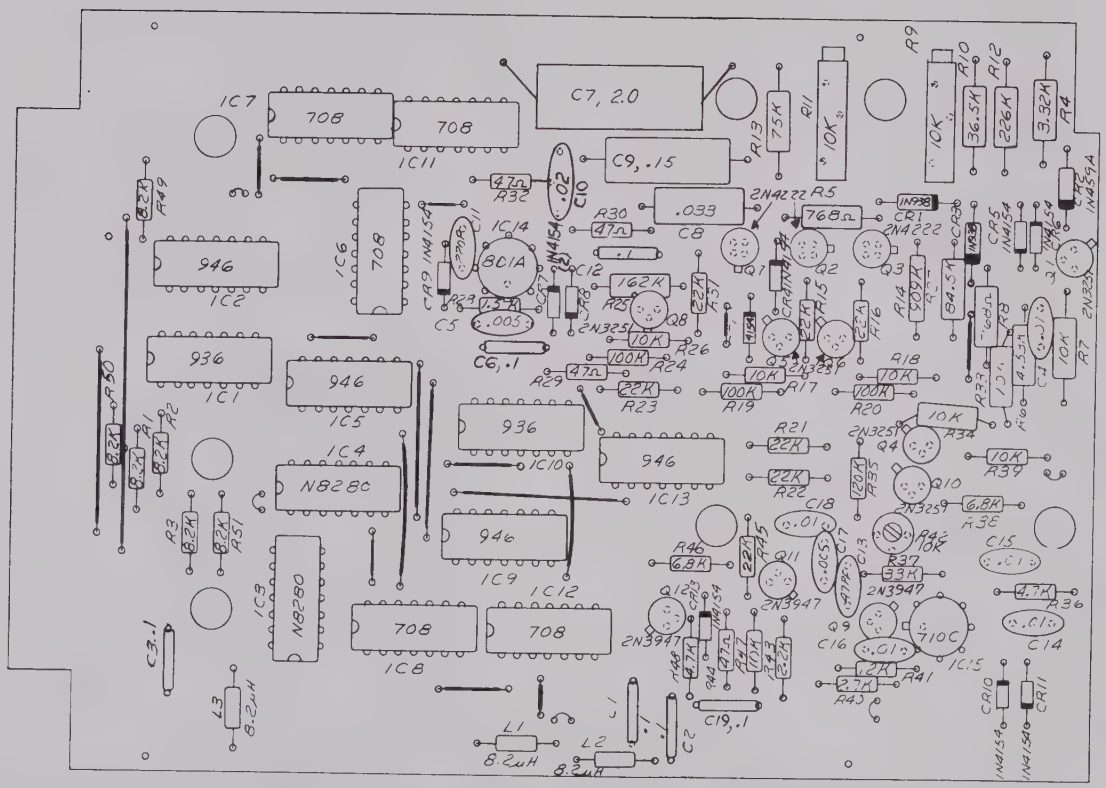
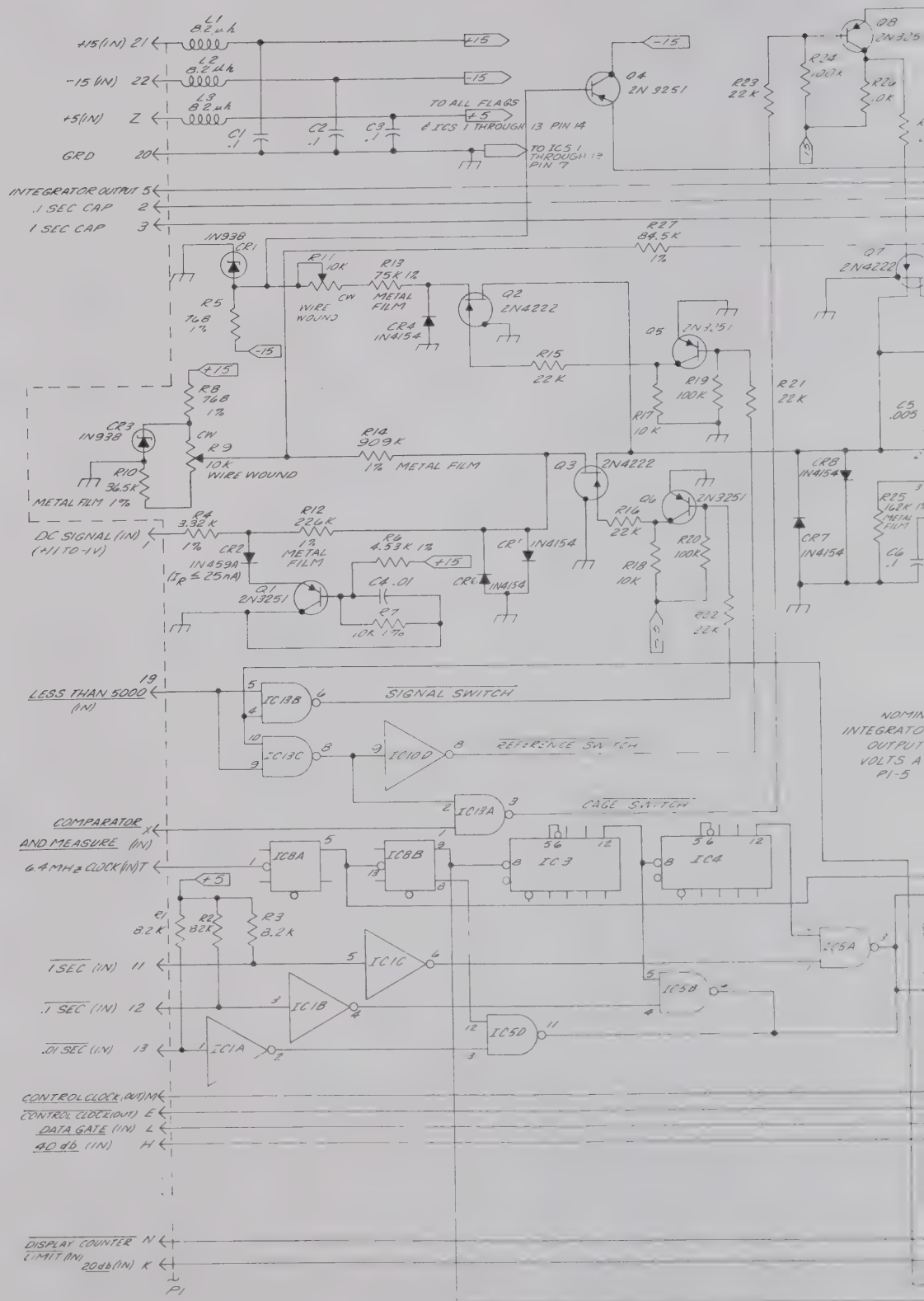


Figure 7-16 Dual Slope Integrator Assembly

A1A5A2



NOTES: 1. REF DES PREFIX (A1A1A2)
2 POSITIVE LOGIC USED THROUGHOUT

IC TYPE	REF DES
SW 708	IC 6, 7, 8, 11, 12
SW 936	IC 1, 10
SW 946	IC 2, 5, 9, 13
N8280A	IC 3, 4
710C	IC 15
801A	IC 14

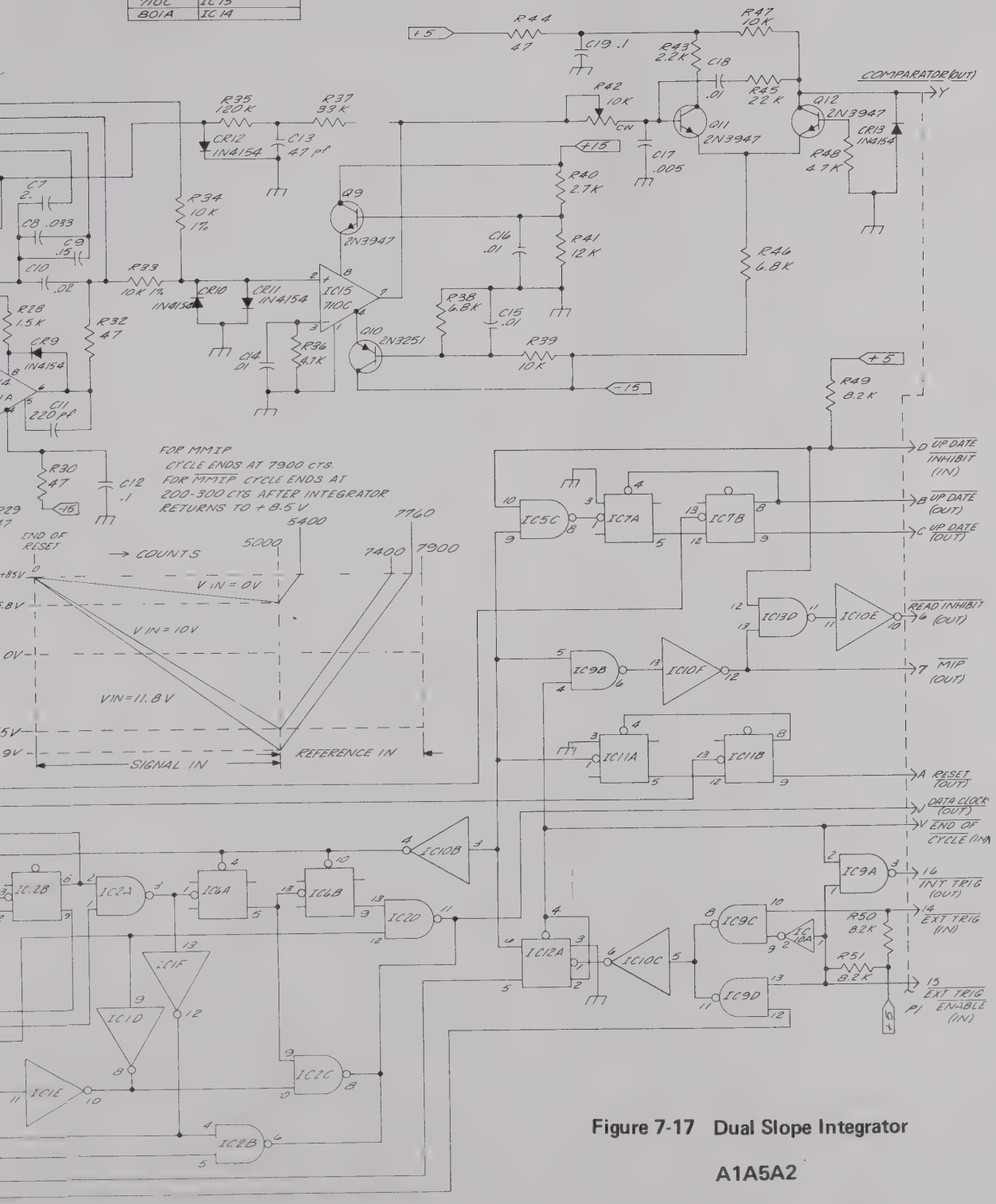


Figure 7-17 Dual Slope Integrator

A1A5A2

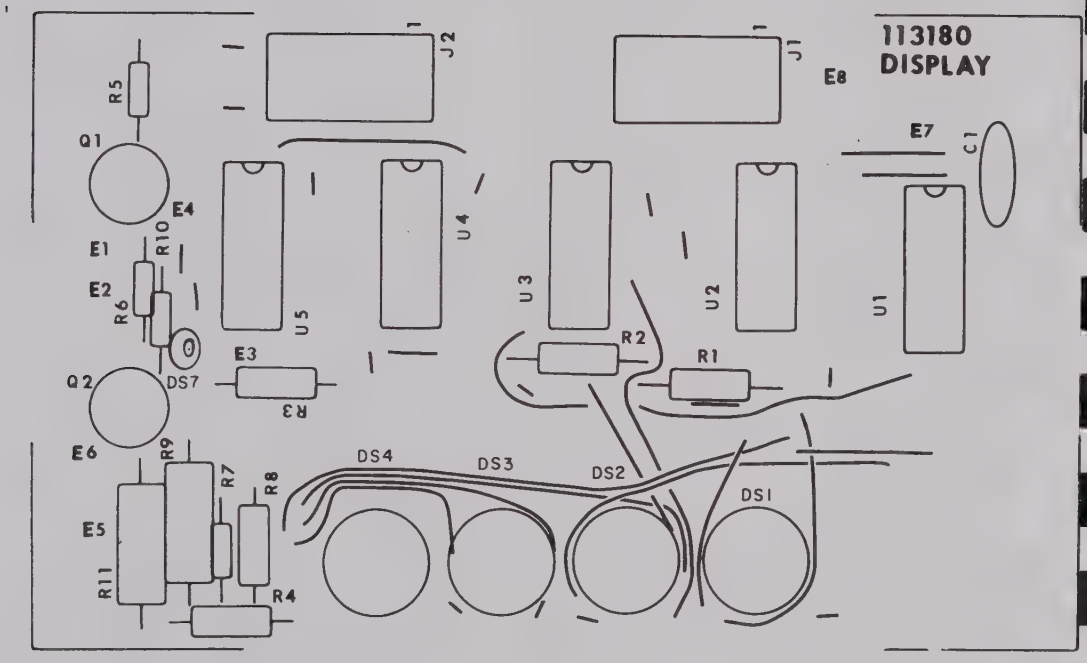
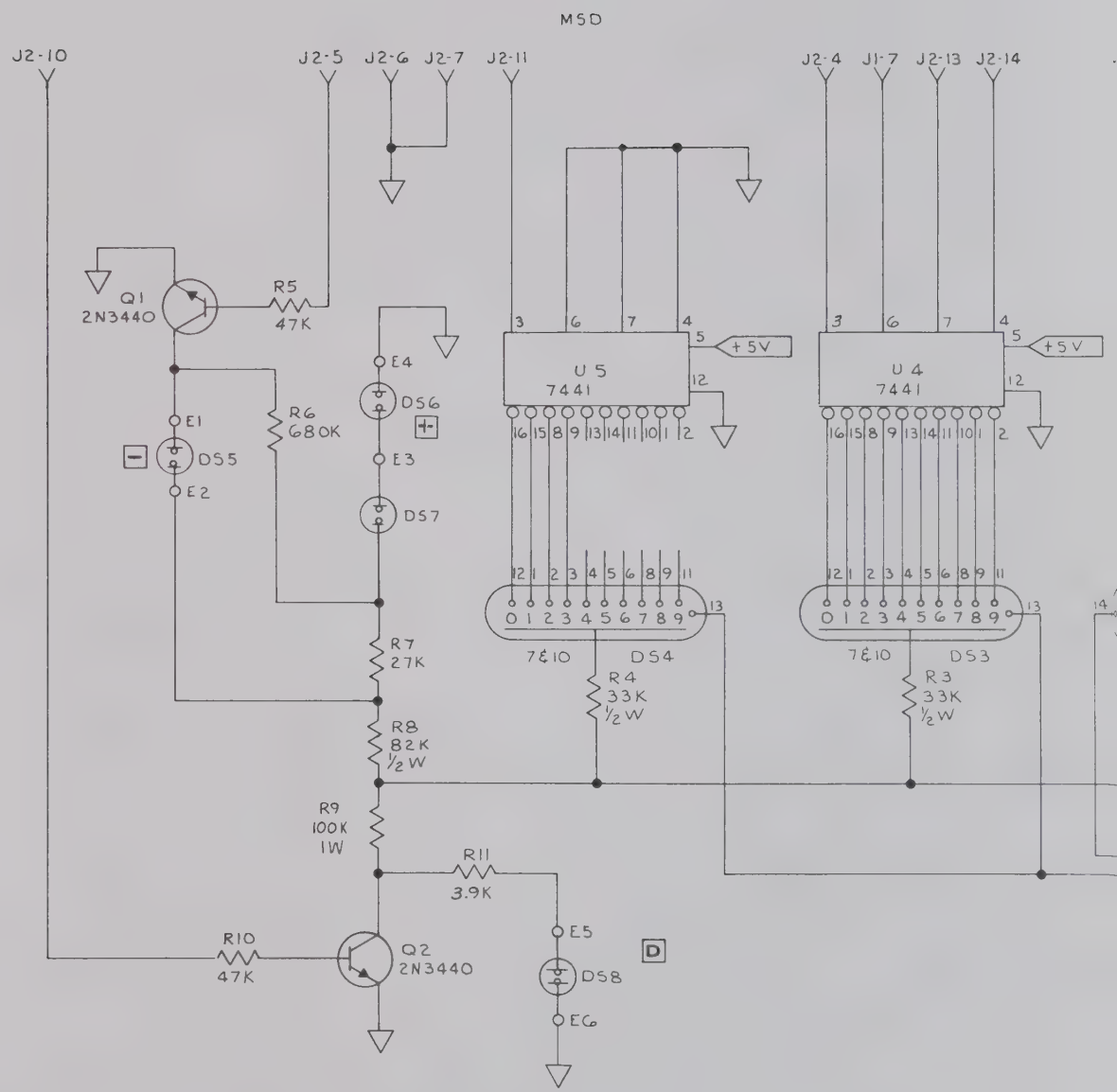


Figure 7-18 Display Module Assembly

A2

113179


MSD
J2-10
J2-5
J2-6
J2-7
J2-11
J2-4
J1-7
J2-13
J2-14
Q1
2N3440
R5
47K
E4
DS6
E1
DS5
E2
E3
DS7
R6
680K
U 5
7441
U 4
7441
+5V
7&10
DS4
DS3
R4
33K
½W
R3
33K
½W
R7
27K
R8
82K
½W
R9
100K
1W
R11
3.9K
R10
47K
Q2
2N3440
E5
DS8
E6
D

13178

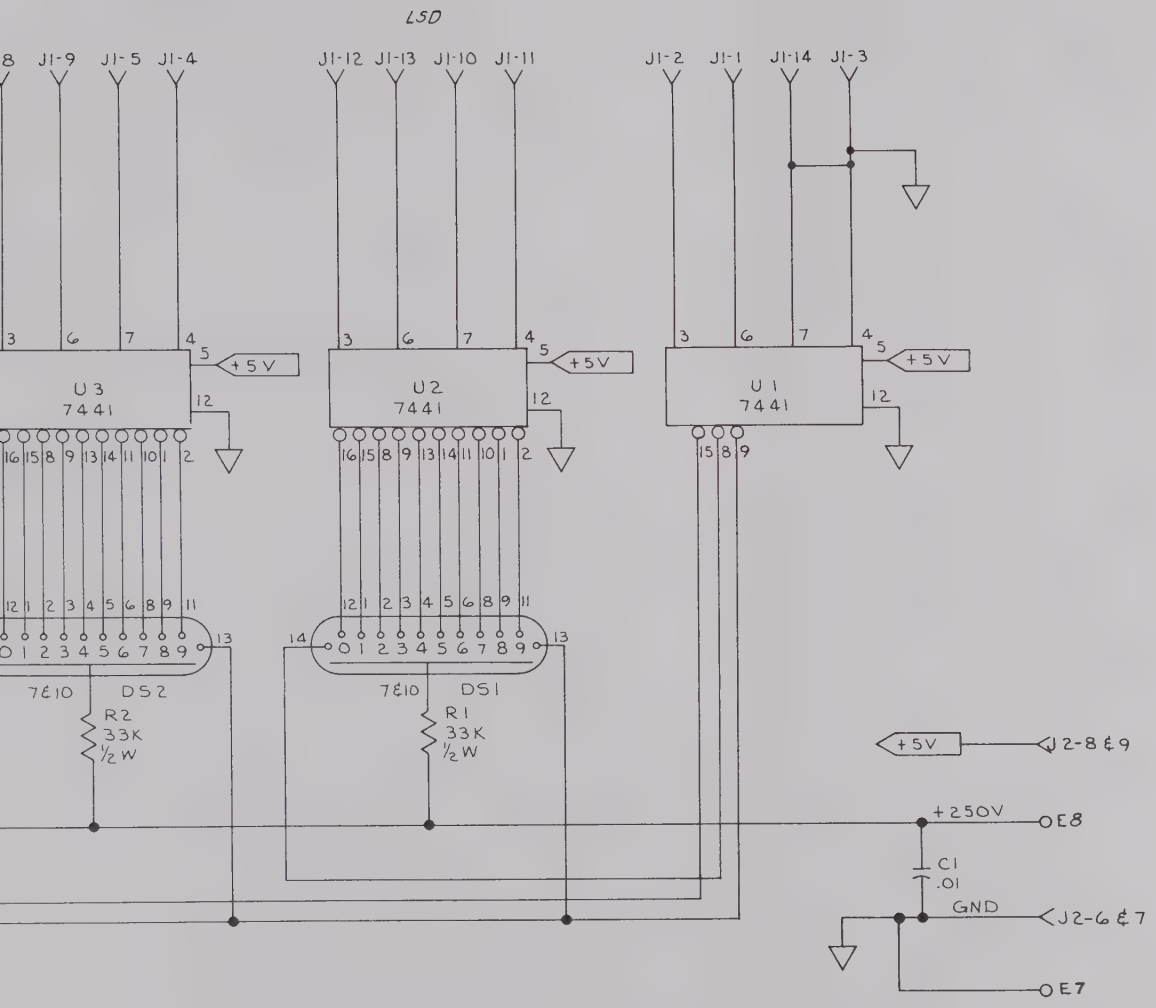
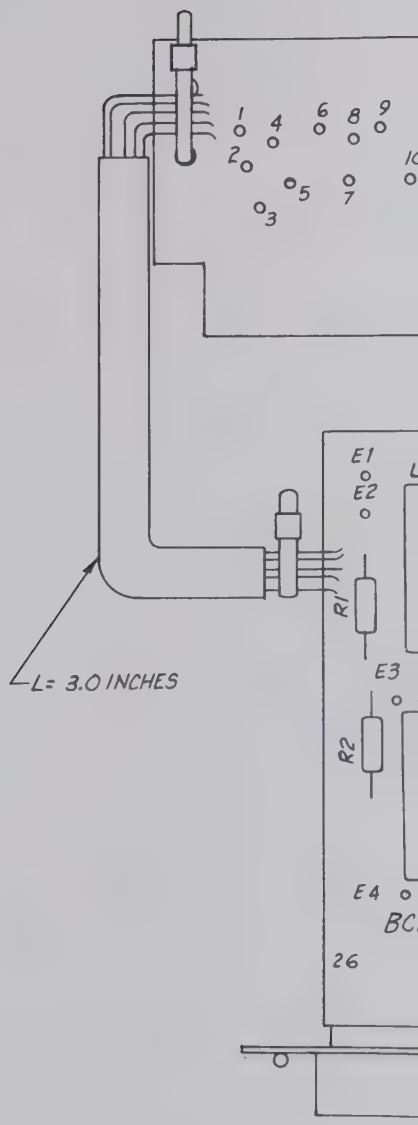


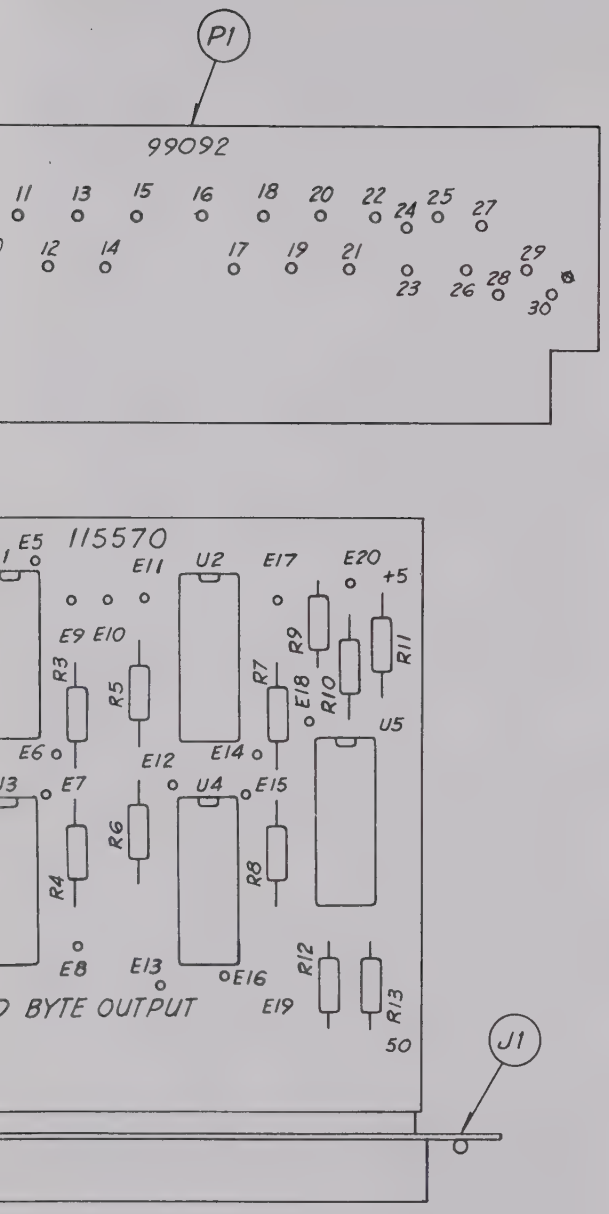
Figure 7-19 Display Module

A2



NOTE:

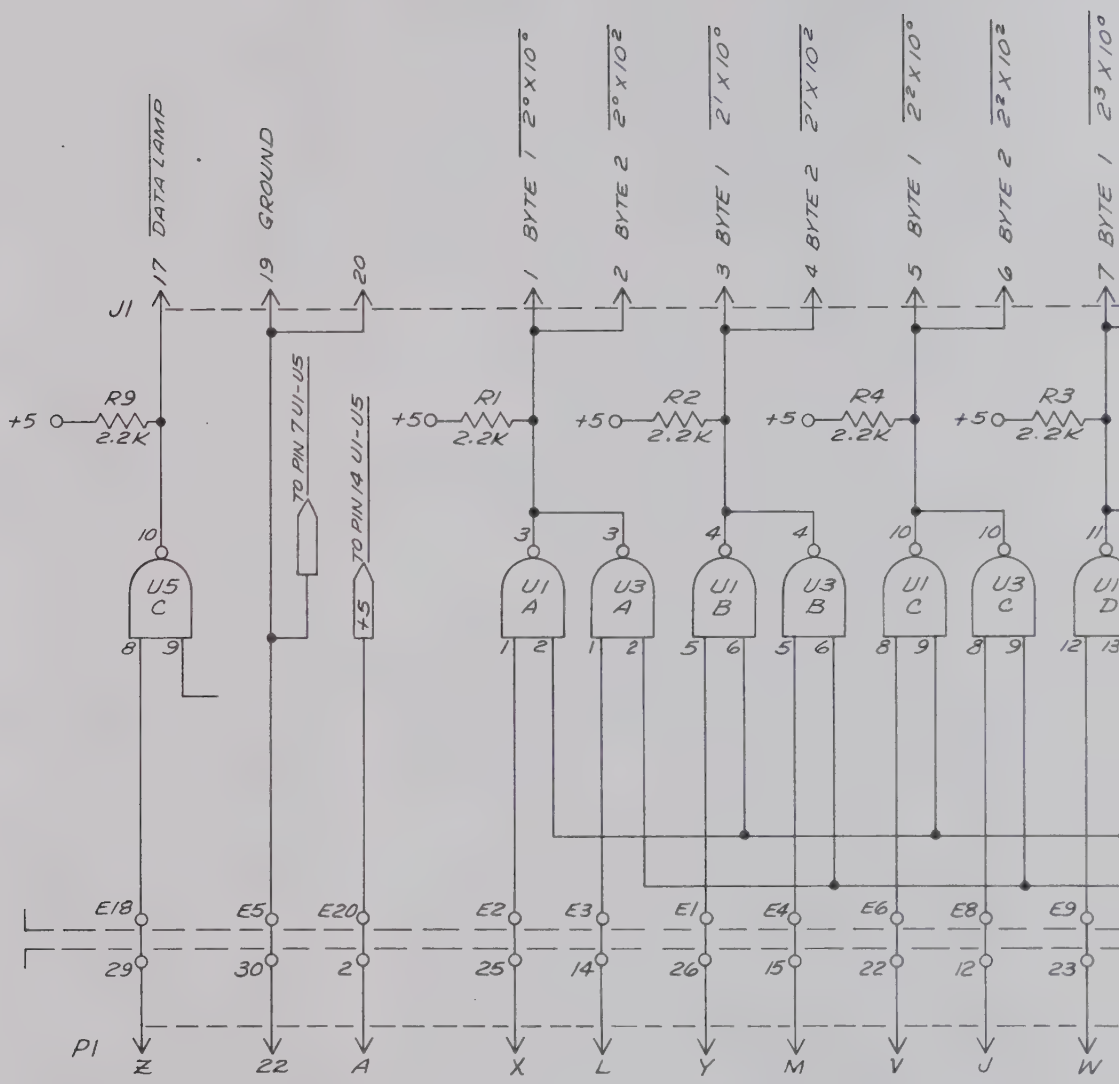
1. ALL WIRE NO. 22 STRANDED



P1 99091	PWB ASSY 115570
1	
2	E20
3	
4	
5	E19
6	E16
7	E13
8	
9	
10	
11	E12
12	E8
13	E7
14	E3
15	E4
16	E14
17	E17
18	E11
19	E10
20	
21	E15
22	E6
23	E9
24	
25	E2
26	E1
27	
28	
29	E18
30	E5

Figure 7-20 BCD Byte Output Assembly

A3*



U1 THROUGH U5 ARE 858P

Figure 7-21 BCD Byte Output

A3*

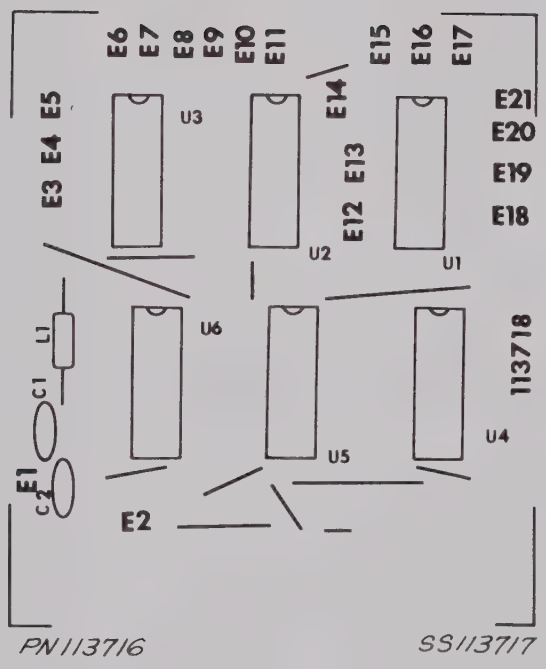
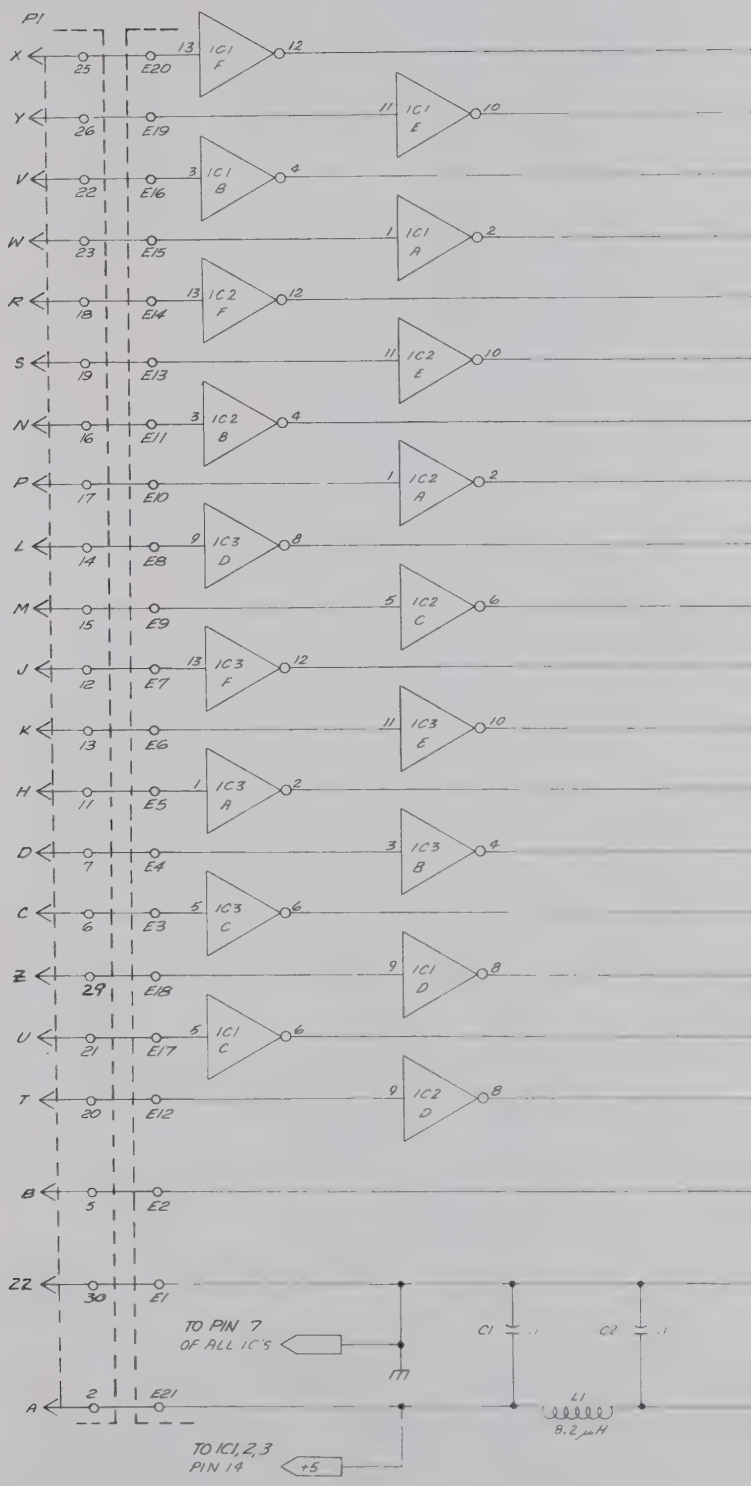
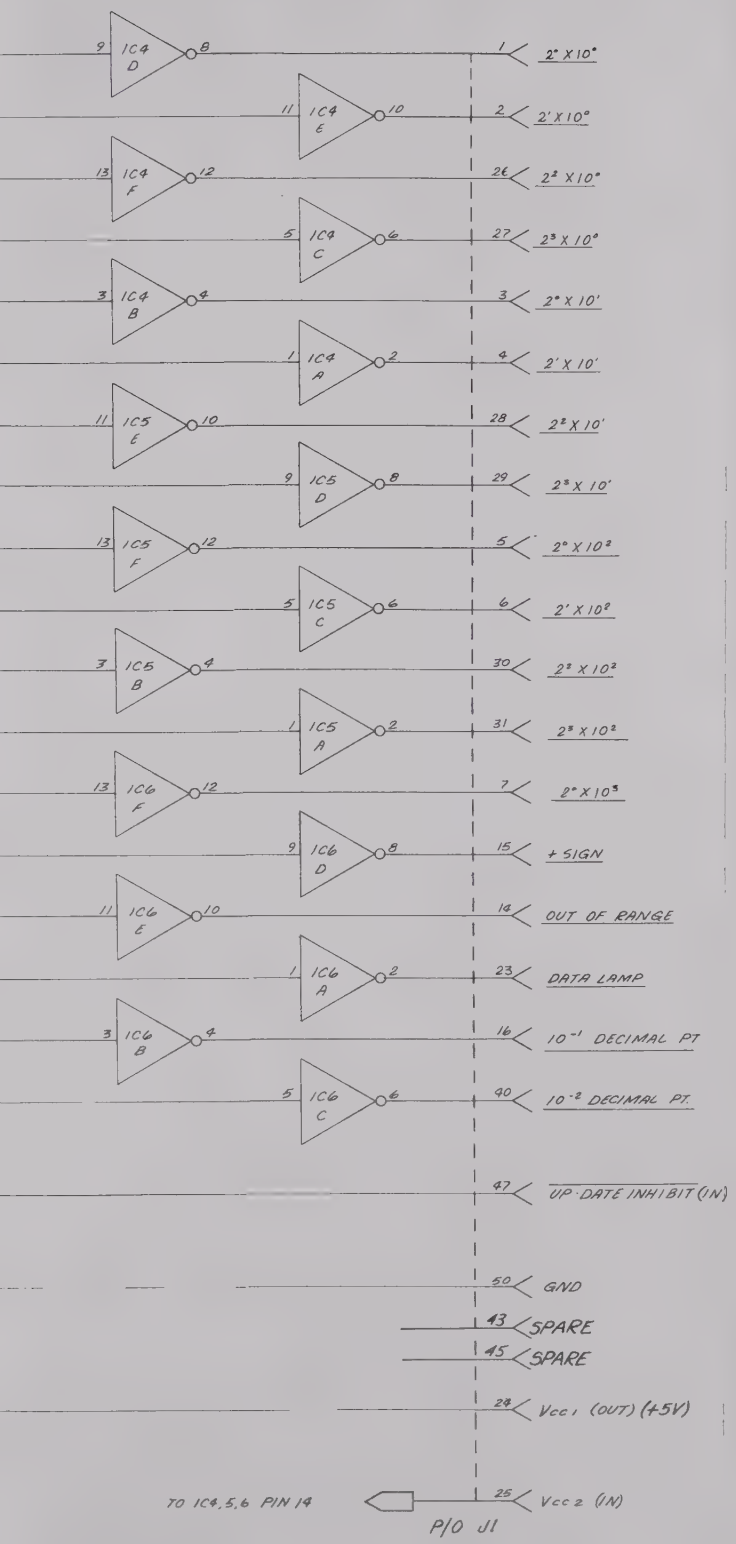
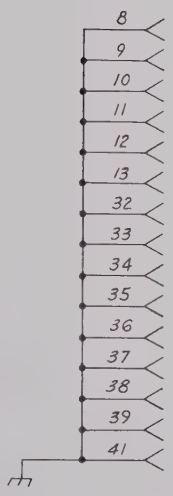


Figure 7-22 BCD Output Assembly

A3*


P1
X
25
E20
13
IC1
F
12
Y
26
E19
11
IC1
E
10
V
22
E16
3
IC1
B
4
W
23
E15
1
IC1
A
2
R
18
E14
13
IC2
F
12
S
19
E13
11
IC2
E
10
N
16
E11
3
IC2
B
4
P
17
E10
1
IC2
A
2
L
14
E8
9
IC3
D
8
M
15
E9
5
IC2
C
6
J
12
E7
13
IC3
F
12
K
13
E6
11
IC3
E
10
H
11
E5
1
IC3
A
2
D
7
E4
3
IC3
B
4
C
6
E3
5
IC3
C
6
Z
29
E18
9
IC1
D
8
U
21
E17
5
IC1
C
6
T
20
E12
9
IC2
D
8
B
5
E2
22
30
E1
TO PIN 7
OF ALL IC'S
C1
.1
C2
.1
L1
8.2 μH
A
2
E21
TO IC1, 2, 3
PIN 14
+5

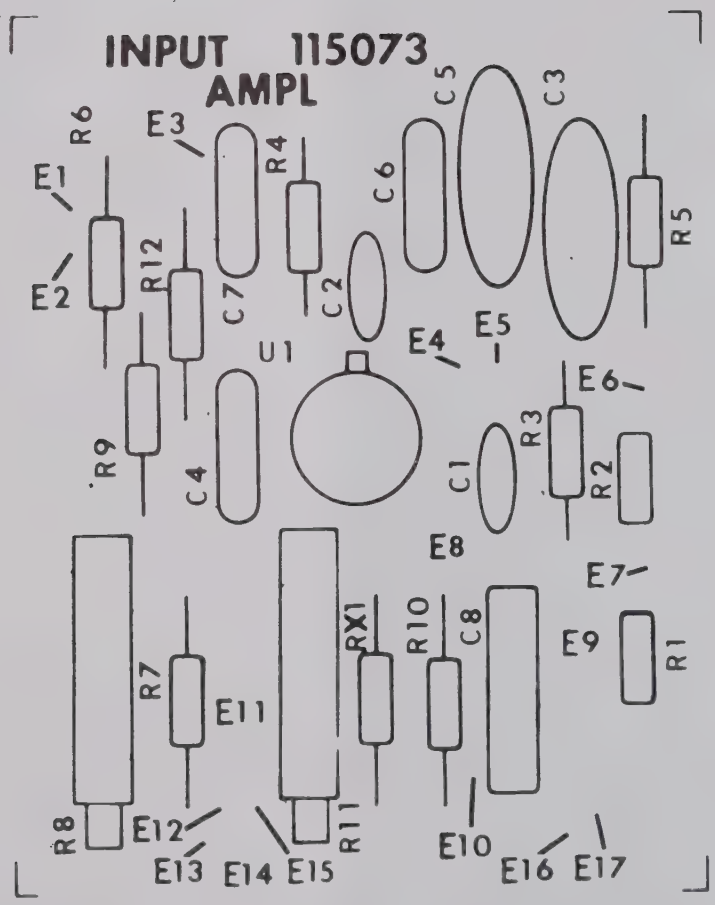




NOTE:
1. IC1,2,3,4,5,6 ARE 936

Figure 7-23 BCD Output

A3*


INPUT 115073
AMPL
R6
E3
E1
R4
C5
C3
C6
R5
E2
R12
C7
C2
E4
E5
U1
E6
R3
R9
C4
C1
R2
E8
E7
RX1
R10
C8
E9
R1
R7
E11
R8
E12
R11
E10
E13
E14
E15
E16
E17

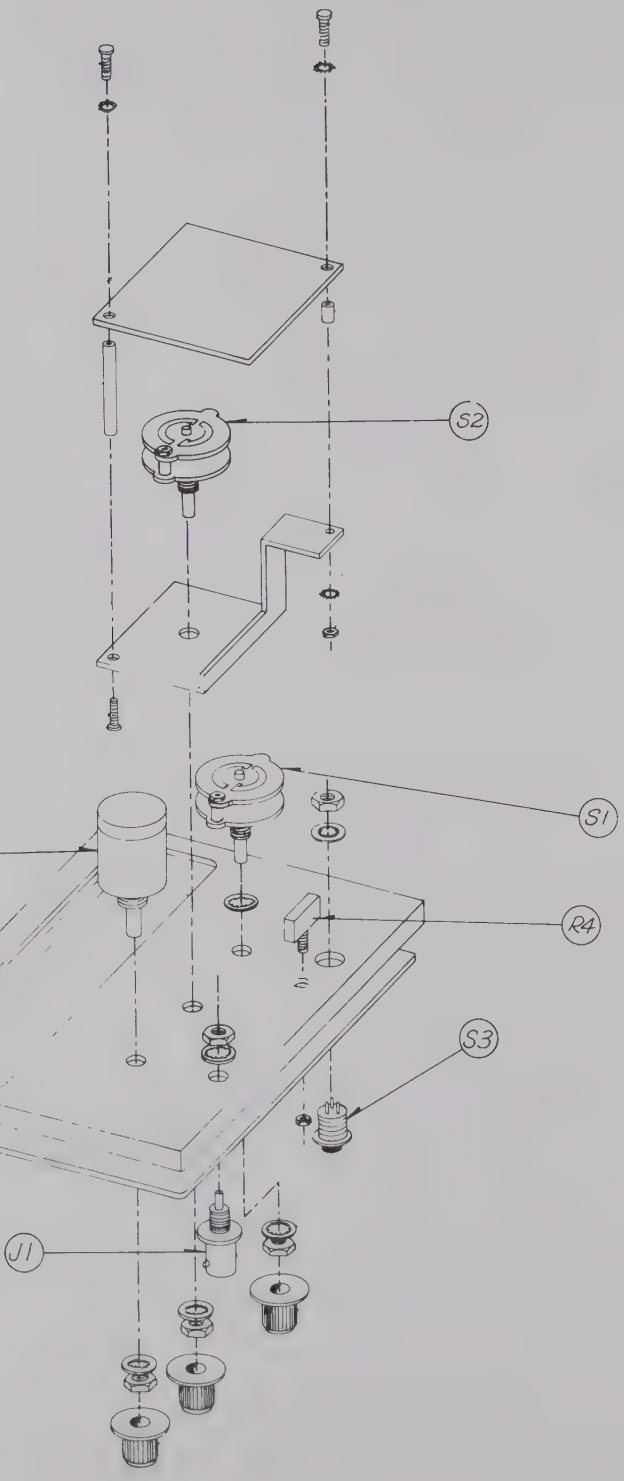
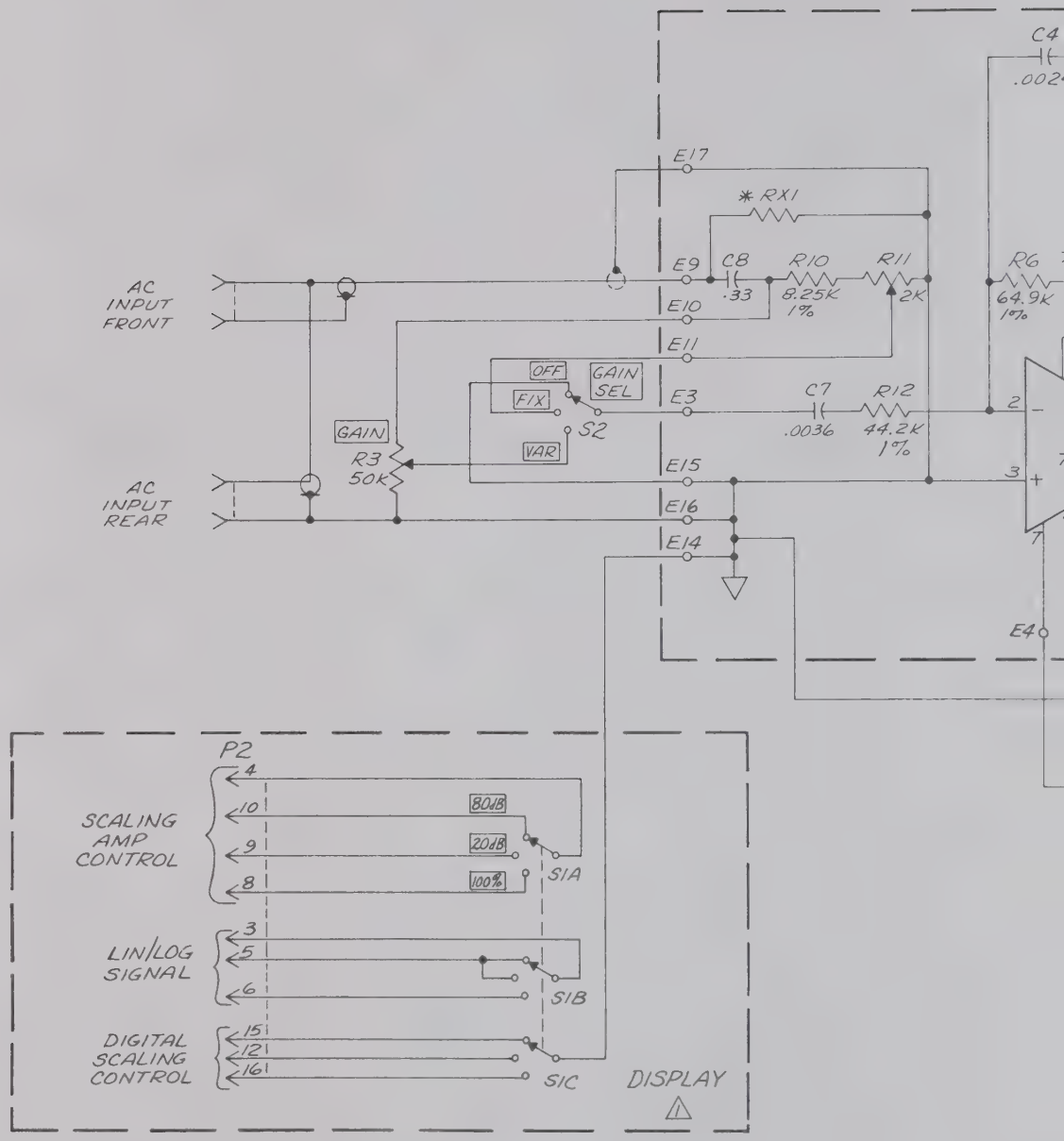


Figure 7-24 . Input Amplifier/Display Assem

A4

115546A



* RX1 AS REQUIRED

⚠ USED ON AMP/DISPLAY MODELS ONLY

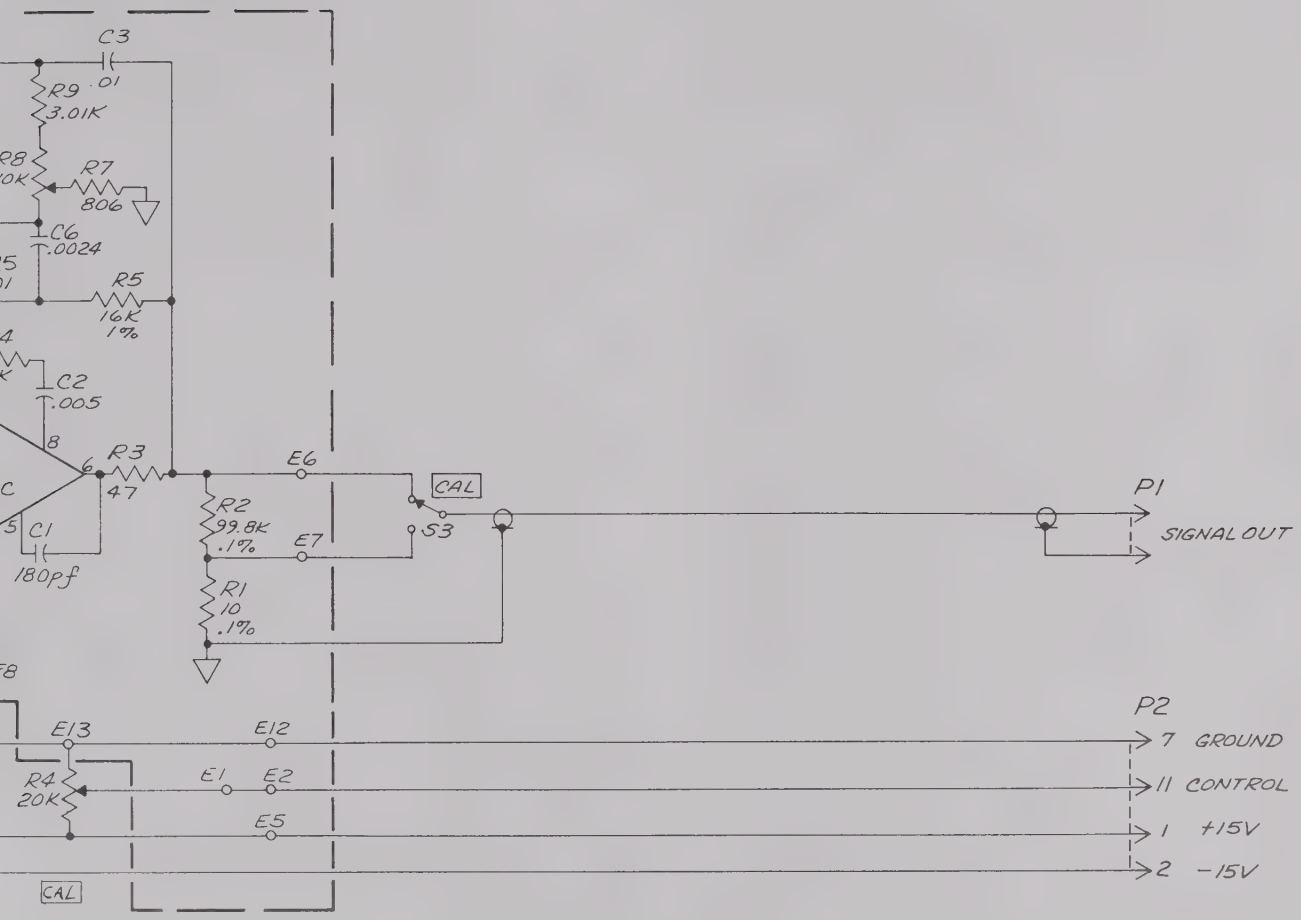
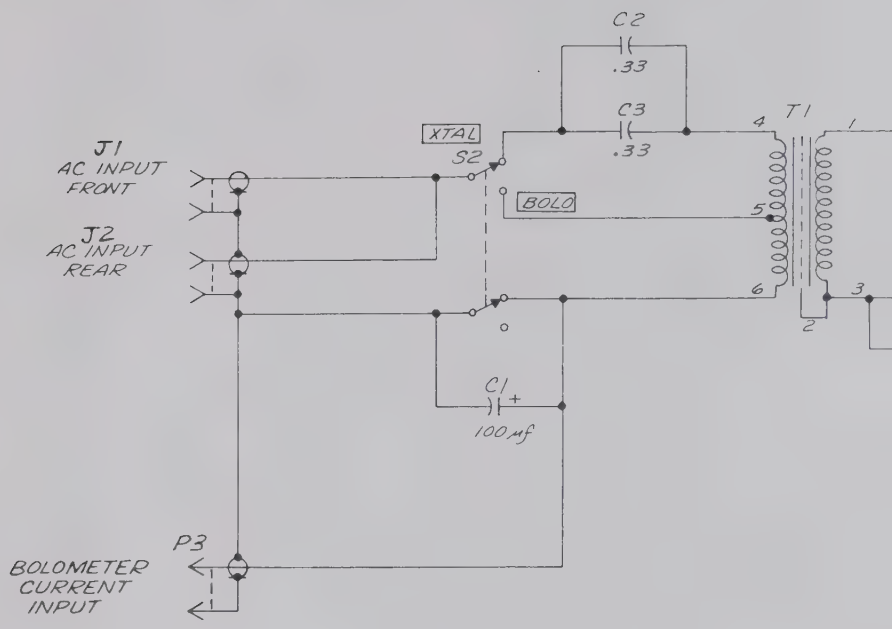


Figure 7-25 Input Amplifier/Display

A4



⚠1 USED ON PREAMP/DISPLAY MODELS ONLY.

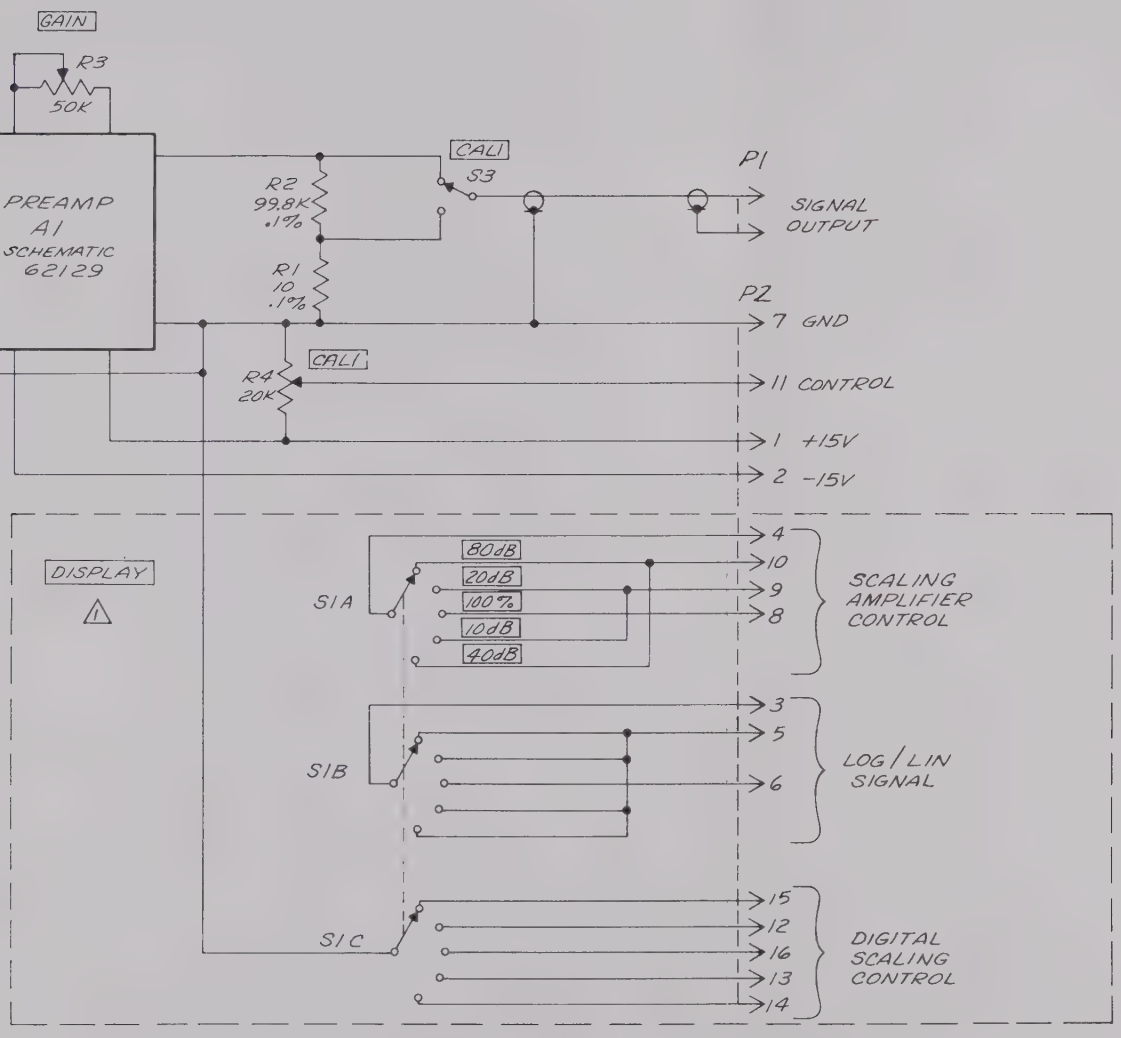
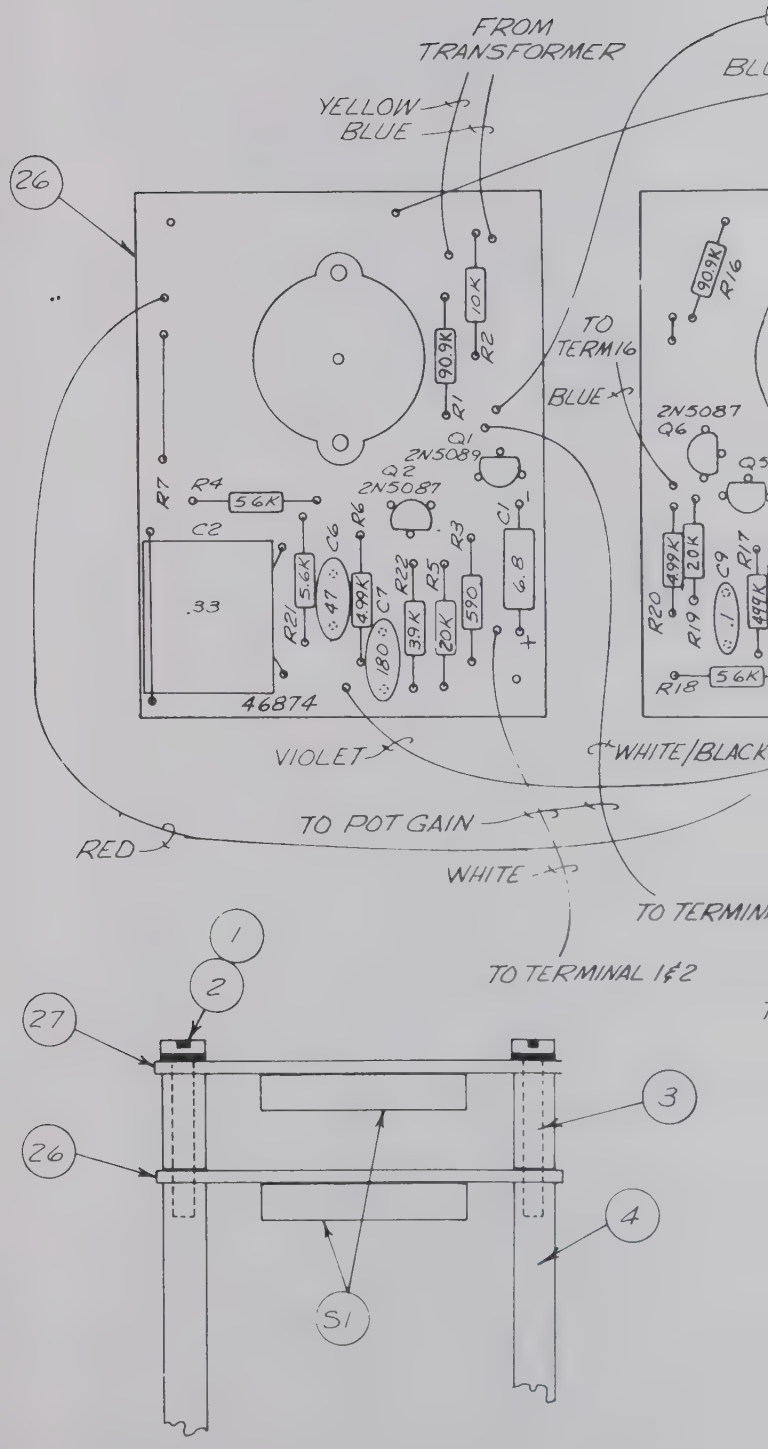


Figure 7-27 Preamplifier and Control Unit

A4*


FROM TRANSFORMER
YELLOW
BLUE
26
R1
90.9K
R2
10K
TO TERM16
BLUE
Q1
2N5089
Q2
2N5087
R7
R4
56K
C2
.33
R6
C6
.47
R3
C1
6.8
R21
5.6K
4.99K
R22
39K
C7
.180
R5
20K
590
46874
2N5087
Q6
R16
90.9K
R20
499K
R19
20K
C9
.1
R17
499K
R18
56K
VIOLET
WHITE/BLACK
TO POT GAIN
RED
WHITE
TO TERMINAL 1&2
1
2
27
26
3
4
S1

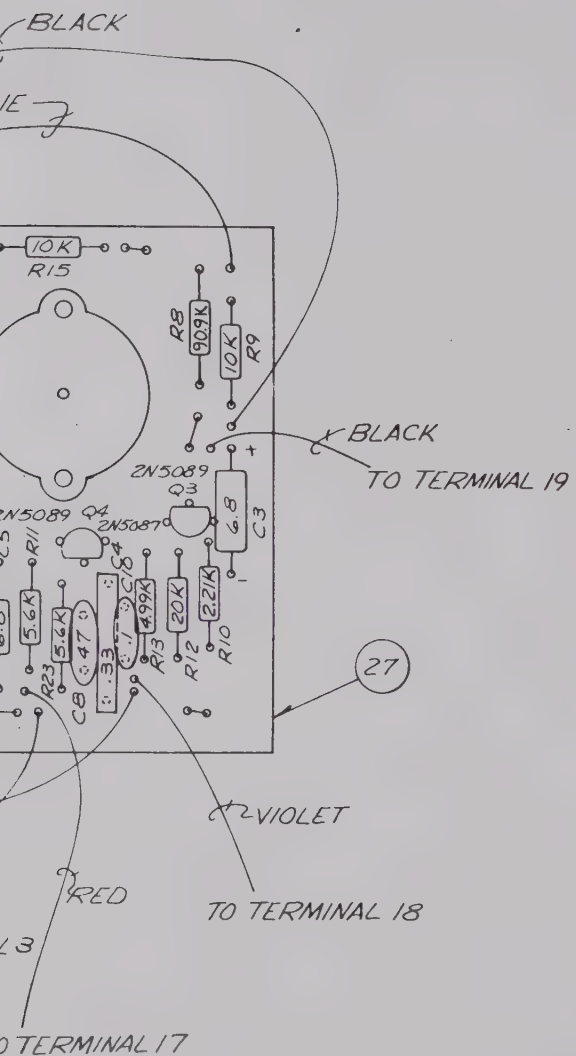
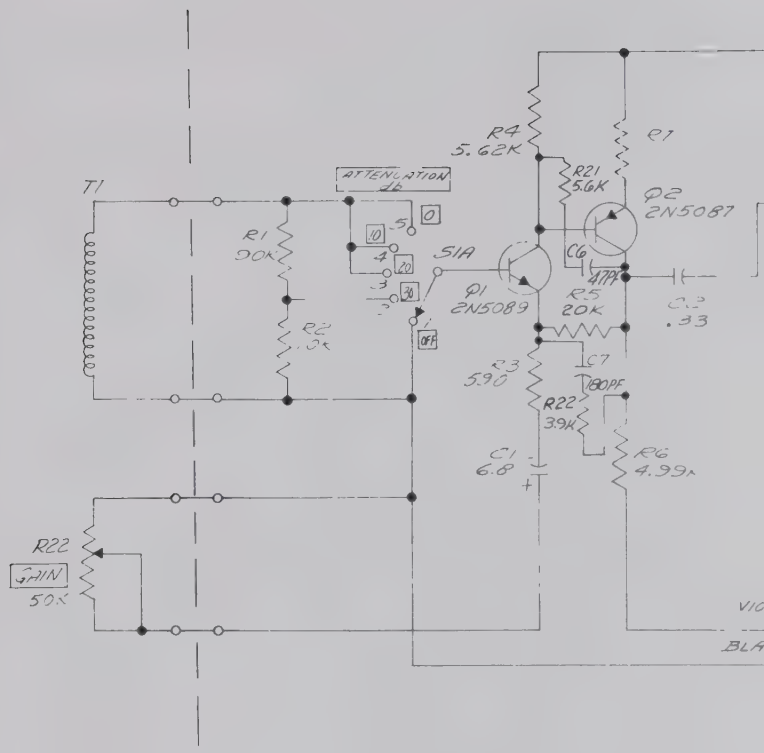


Figure 7-28 CBA Preamplifier Assembly



NOTE

1 PARTIAL REFERENCE DESIGNATIONS ARE SHOWN PREFIX WITH UNIT NUMBER ON SUBASSEMBLY DESIGNATION(S) OR BOTH FOR COMPLETE DESIGNATION

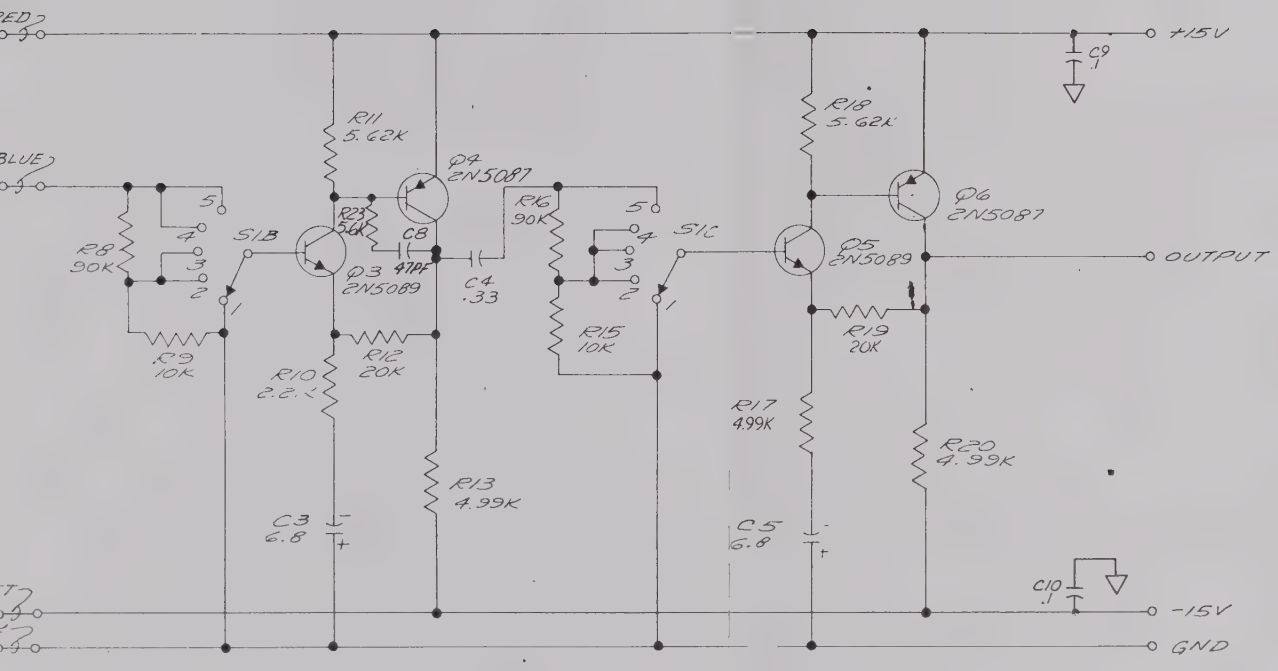


Figure 7-29. CBA Preamplifier

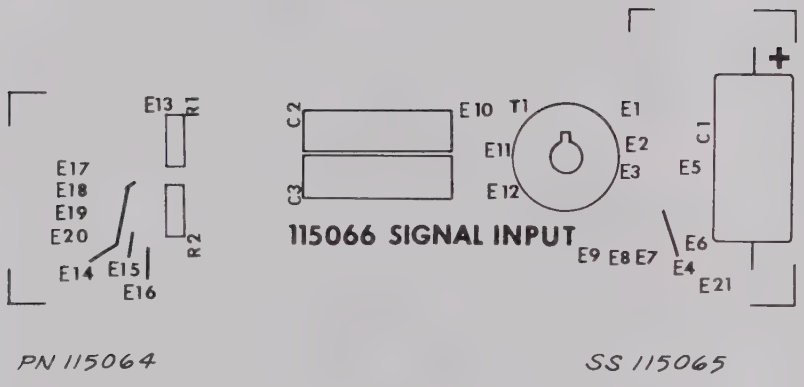
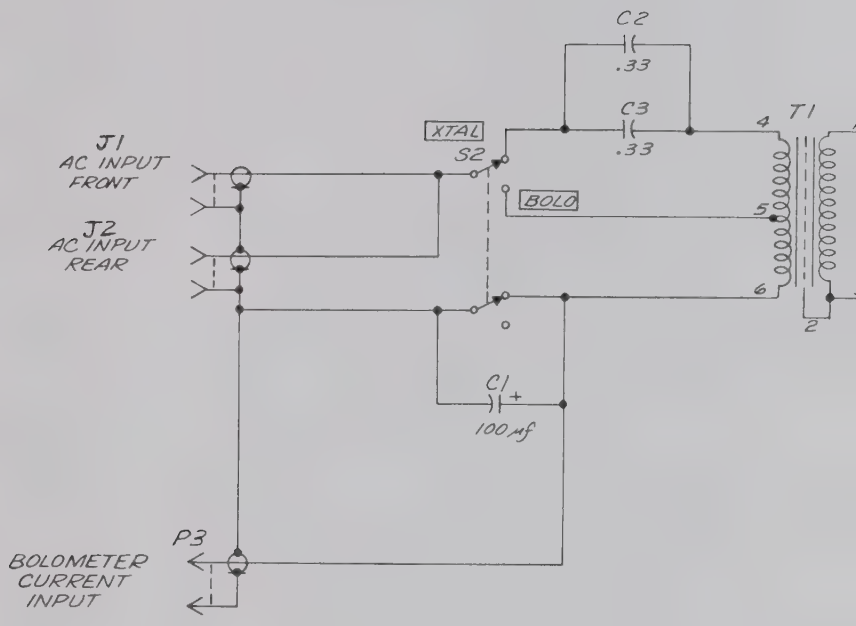


Figure 7-30 Signal Input Assembly

A4*A1

115065



⚠1 USED ON PREAMP/DISPLAY MODELS ONLY.

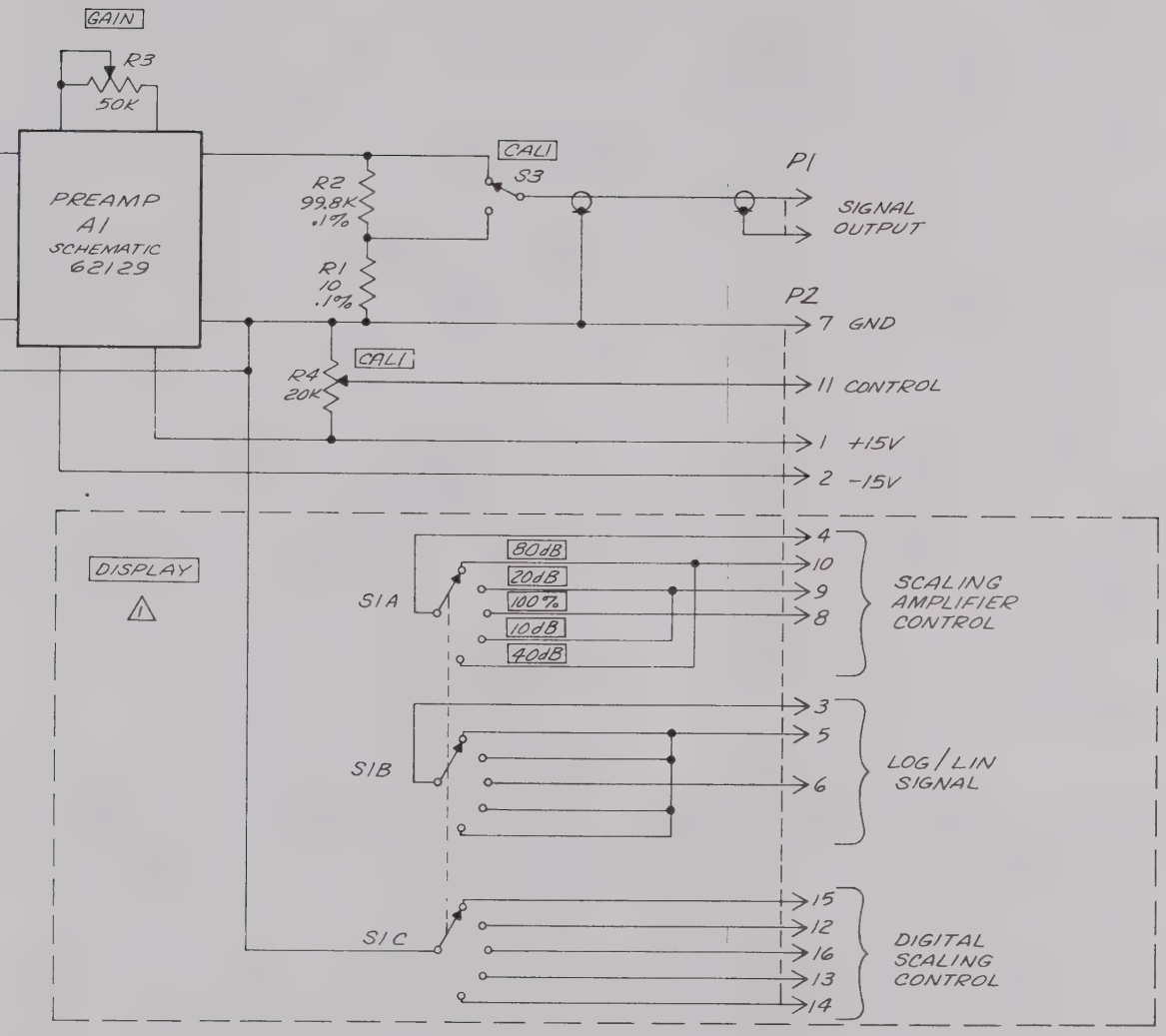
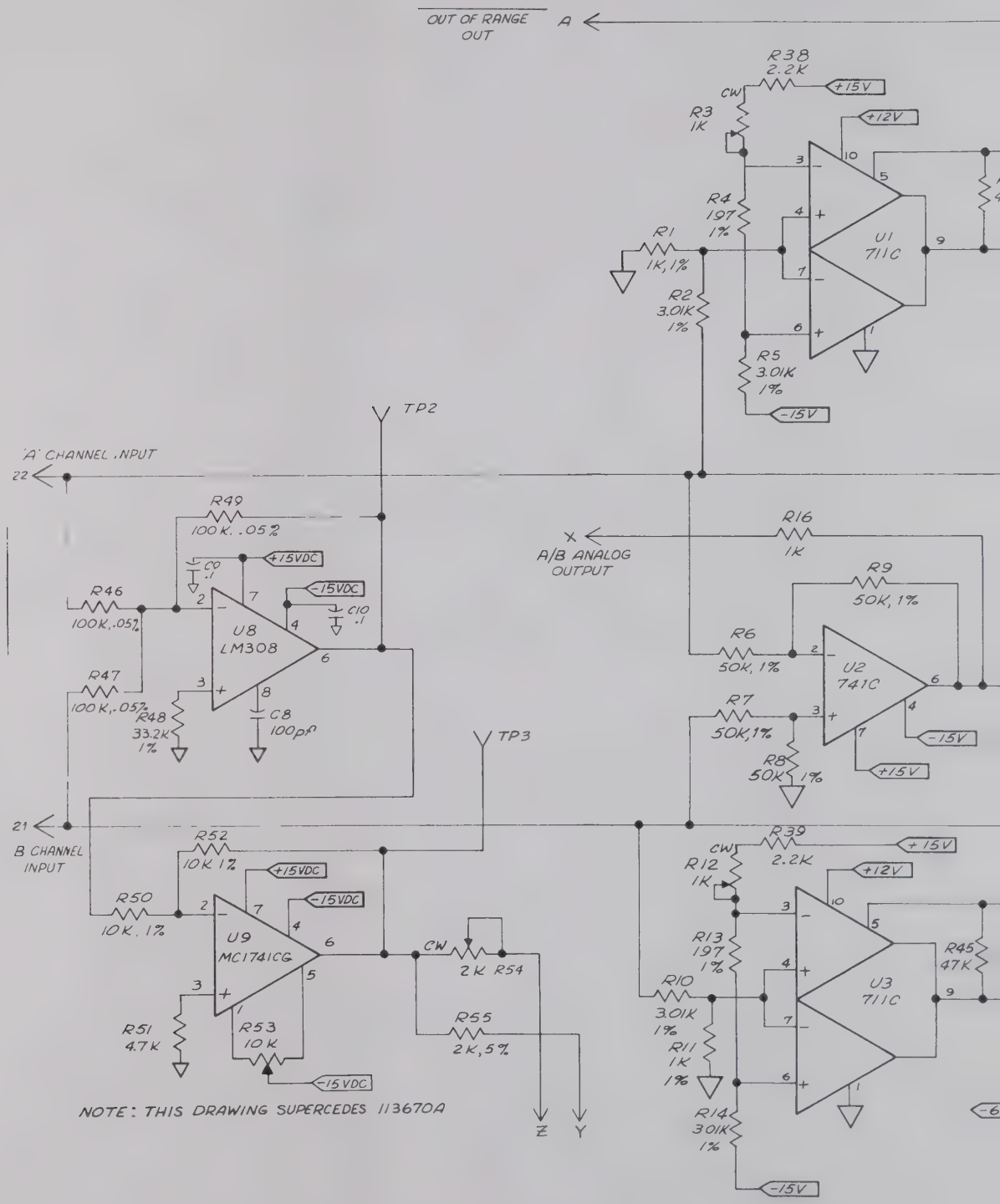


Figure 7-31 Preamplifier and Control Unit

A4*A1



NOTE: THIS DRAWING SUPERCEDES 113670A

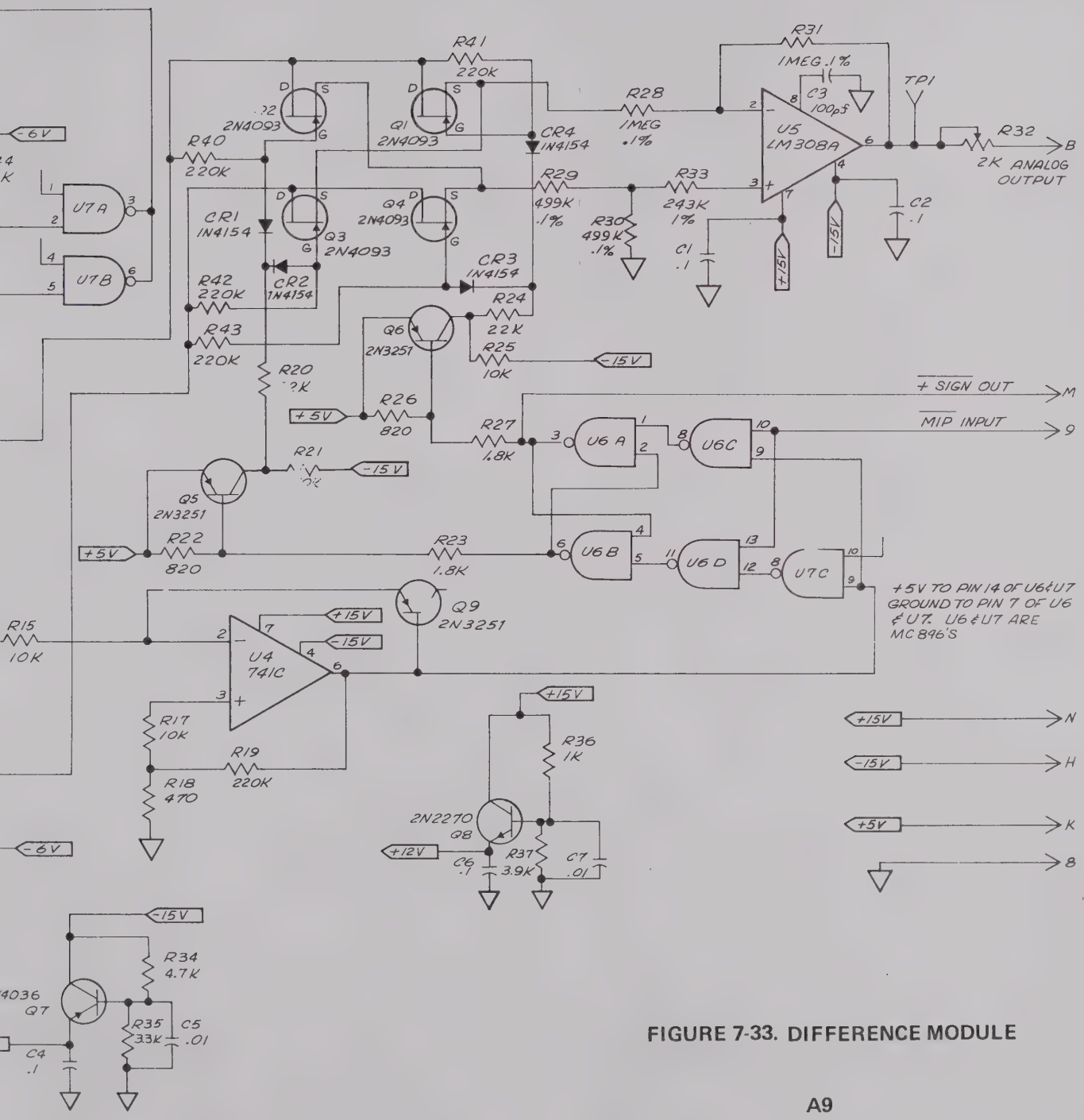


FIGURE 7-33. DIFFERENCE MODULE

A9

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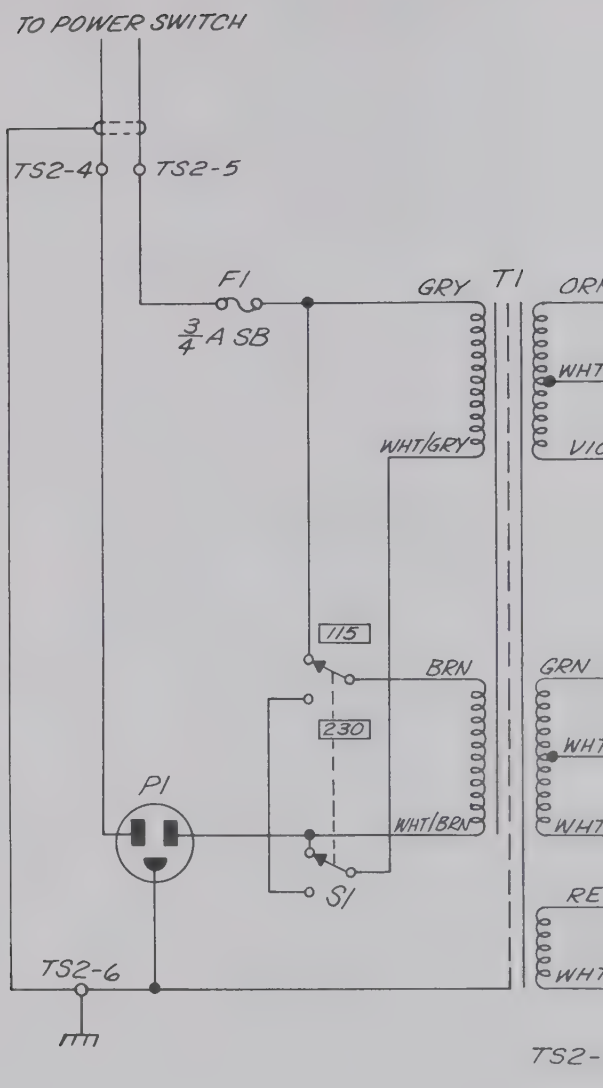

TO POWER SWITCH
TS2-4
TS2-5
F1
3/4 A SB
GRY
T1
WHT/GRY
115
230
BRN
WHT/BRN
P1
S1
TS2-6
GRN
TS2-

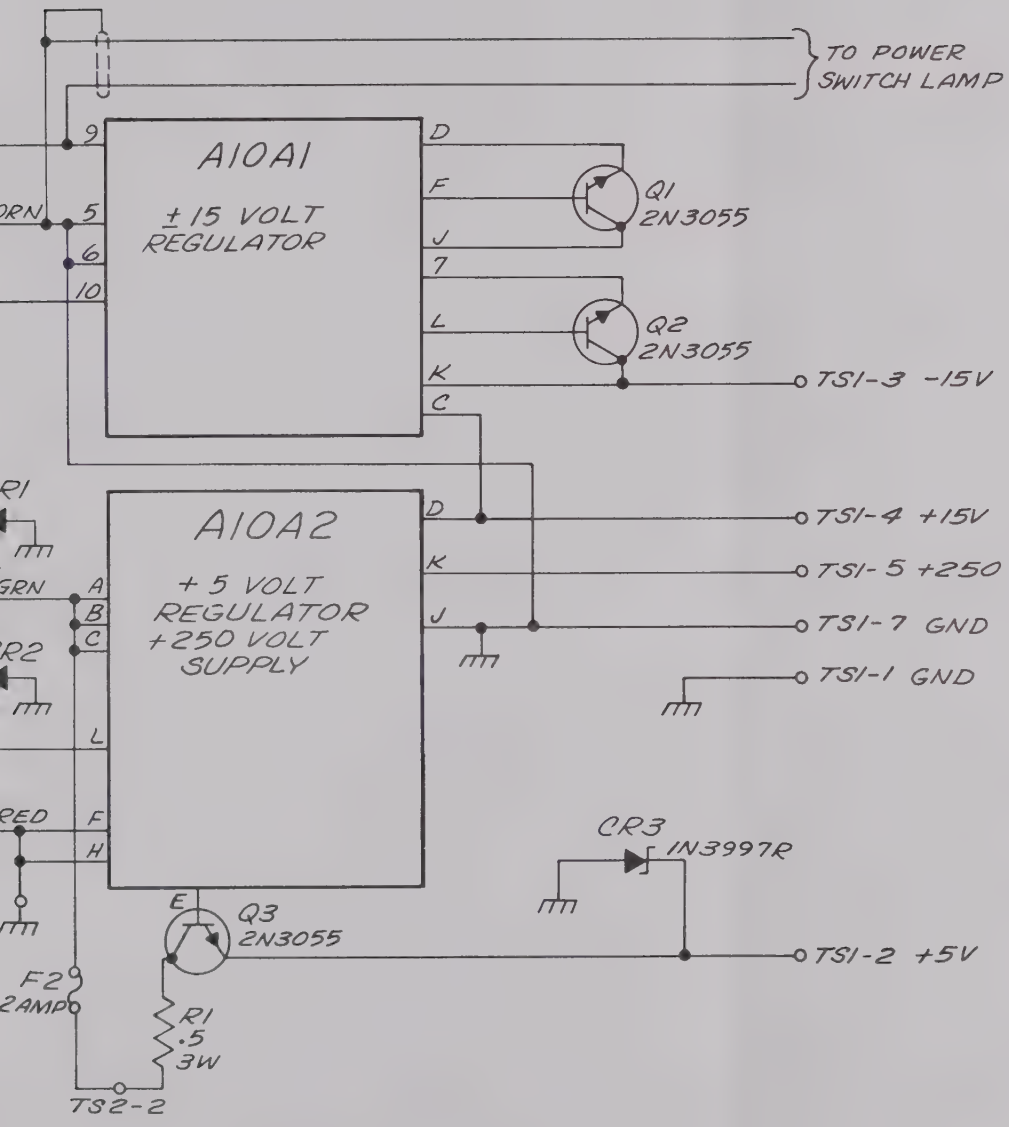


FIGURE 7-34. Overall Power Supply

A10

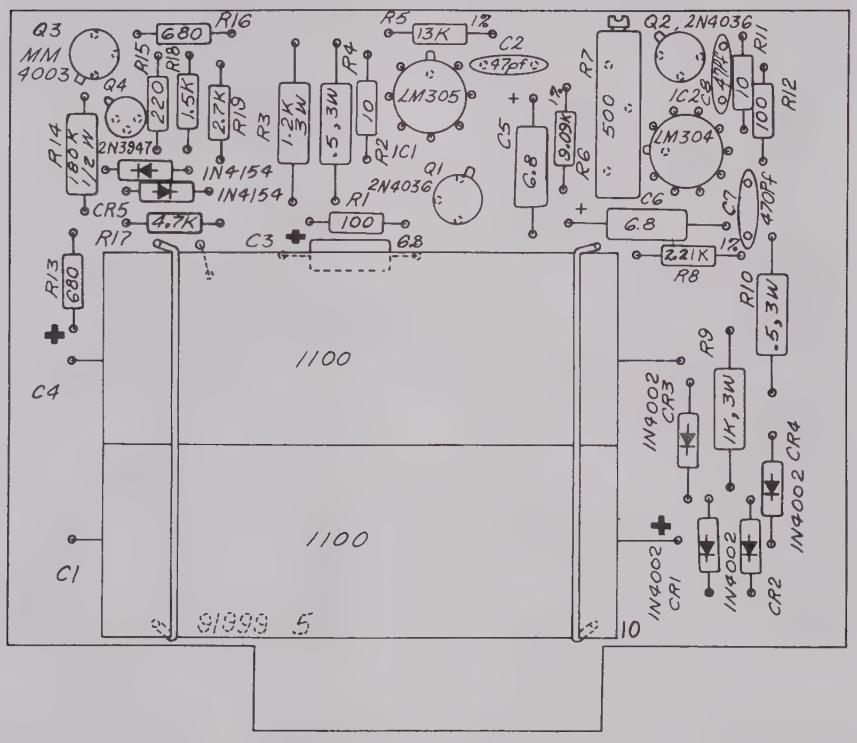
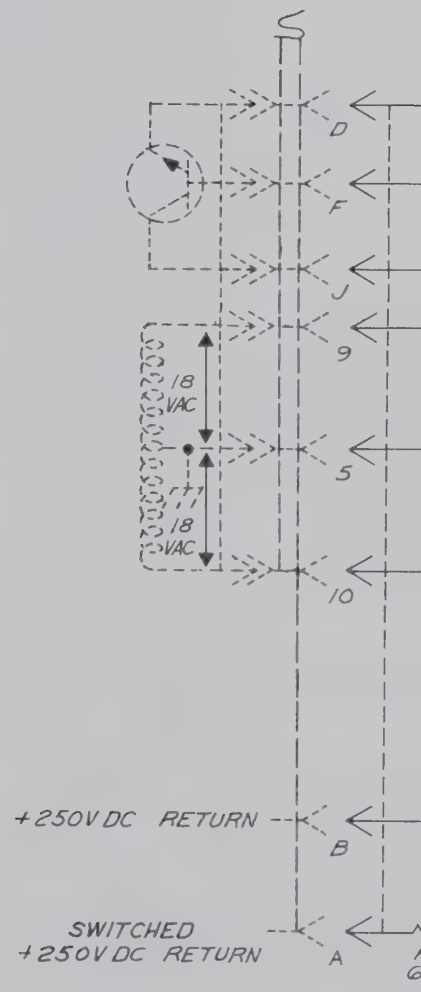


FIGURE 7-35 ± 15 Volt Power Supply Assembly

A10A1

91999C


D
F
J
9
18 VAC
5
18 VAC
10
+250V DC RETURN
B
SWITCHED +250V DC RETURN
A

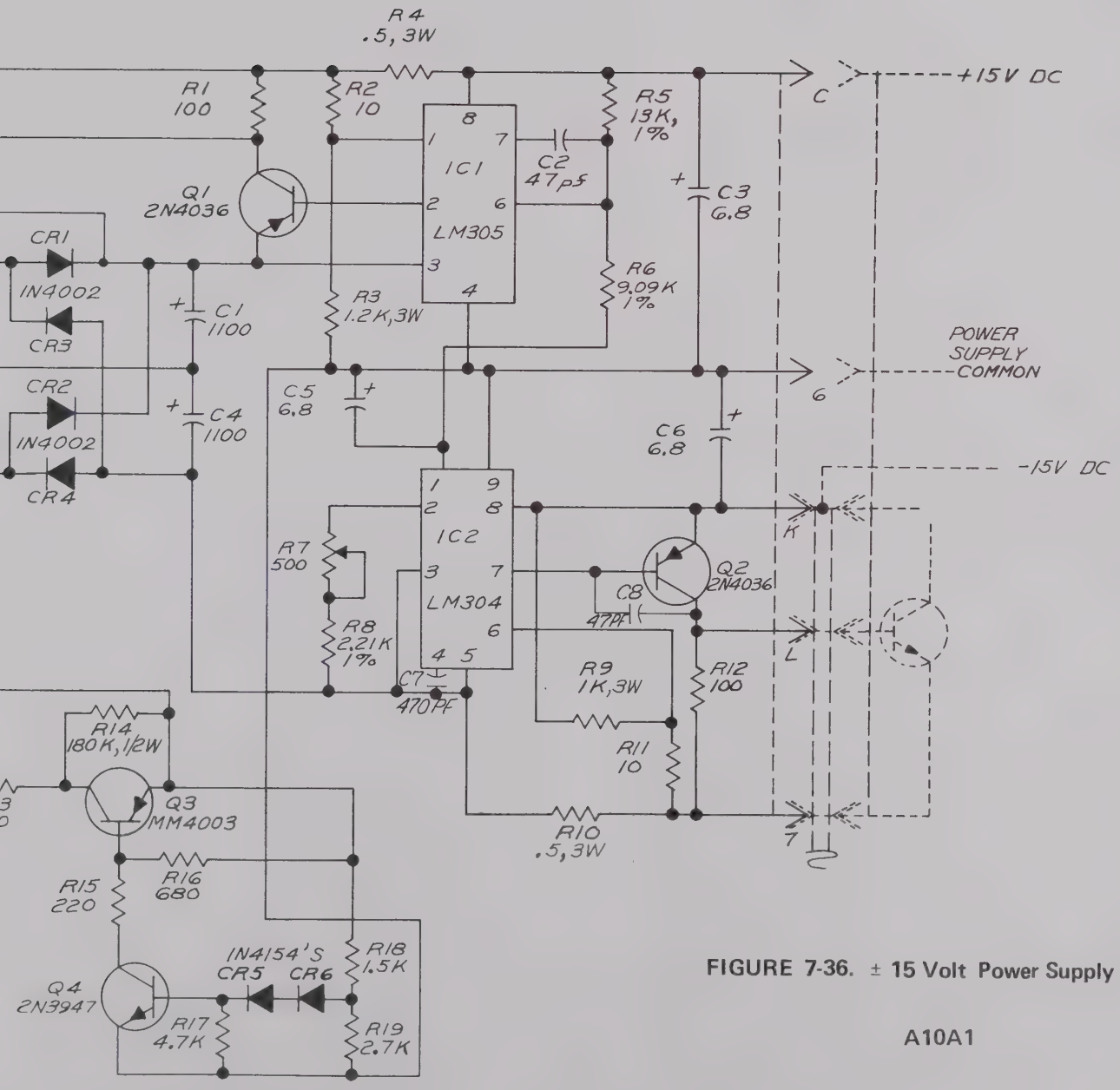


FIGURE 7-36. ± 15 Volt Power Supply

A10A1

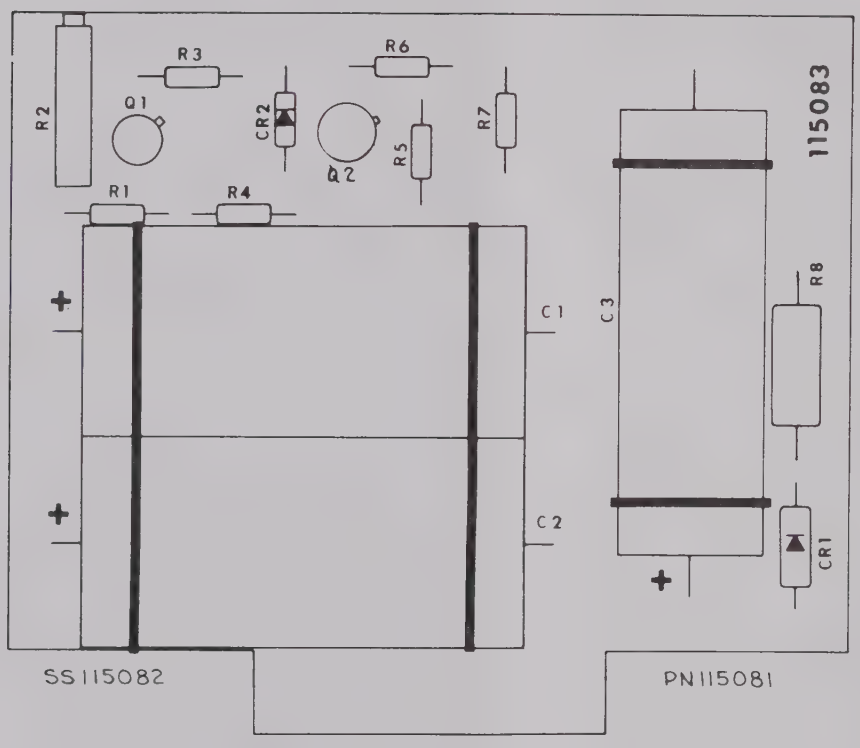


FIGURE 7-37 5 Volt & 250 Volt Power Supply Assembly

A10A2

115083A

+15

+5
UNREG

+2
RET

190V

+2

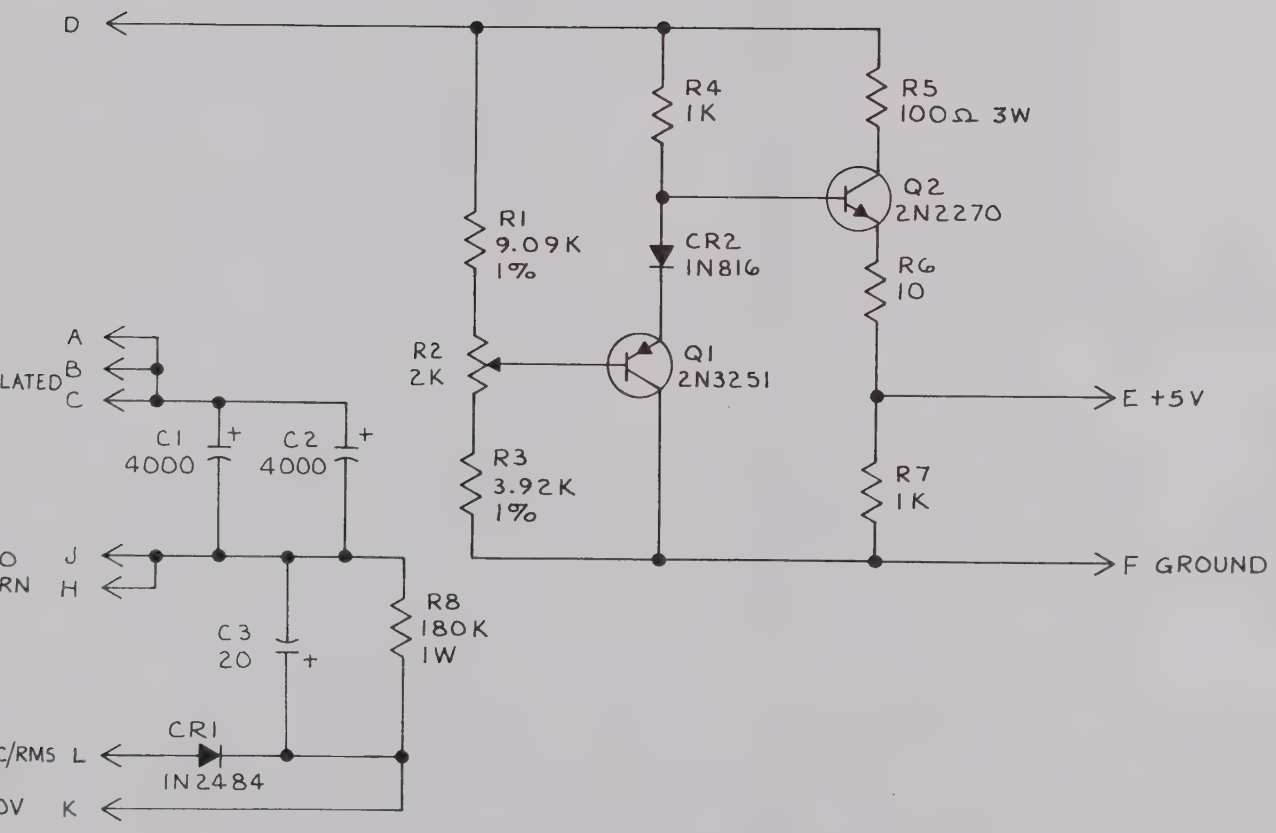


Figure 7-38. 5-Volt and 250 Volt Power Supply A10A2

CONVERSION OF VOLTAGE AND POWER RATIOS TO DECIBELS

The basic chart below indicates the number of decibels (dB) corresponding to the listed ratios of voltage or power over the range of −20 to +20 dB. For voltage or power ratios greater than those included in the chart, the ratio can be broken down into a product of two numbers, the value in dB for each found separately, and the two results added. Example: To convert a power ratio of 2,000:1 to dB, express 2,000 as 2×10^3; the number of dB corresponding to a power ratio of 2 is very nearly 3, and the number of dB for a power ratio of 10^3 is 30. Therefore, the power ratio of 2,000:1 is approximately 30 dB + 3 dB = 33 dB. In the lower righthand corner of the chart dB values for voltage and power ratios of integral powers of 10 are given.

Voltage Ratio	*Power Ratio*	*−dB+*	*Voltage Ratio*	*Power Ratio*	*Voltage Ratio*	*Power Ratio*	*−dB+*	*Voltage Ratio*	*Power Ratio*	*Voltage Ratio*	*Power Ratio*	*−dB+*	*Voltage Ratio*	*Power Ratio*
1.000	**1.000**	**0**	**1.000**	**1.000**	**.447**	**.200**	**7.0**	**2.239**	**5.012**	**.200**	**.0398**	**14.0**	**5.012**	**25.12**
.989	.977	.1	1.012	1.023	.442	.195	7.1	2.265	5.129	.197	.0389	14.1	5.070	25.70
.977	.955	.2	1.023	1.047	.437	.191	7.2	2.291	5.248	.195	.0380	14.2	5.129	26.30
.966	.933	.3	1.035	1.072	.432	.186	7.3	2.317	5.370	.193	.0372	14.3	5.188	26.92
.955	.912	.4	1.047	1.096	.427	.182	7.4	2.344	5.495	.191	.0363	14.4	5.248	27.54
.944	.891	.5	1.059	1.122	.422	.178	7.5	2.371	5.623	.188	.0355	14.5	5.309	28.18
.933	.871	.6	1.072	1.148	.417	.174	7.6	2.399	5.754	.186	.0347	14.6	5.370	28.84
.923	.851	.7	1.084	1.175	.412	.170	7.7	2.427	5.888	.184	.0339	14.7	5.433	29.51
.912	.832	.8	1.096	1.202	.407	.166	7.8	2.455	6.026	.182	.0331	14.8	5.495	30.20
.902	.813	.9	1.109	1.230	.403	.162	7.9	2.483	6.166	.180	.0324	14.9	5.559	30.90
.891	**.794**	**1.0**	**1.122**	**1.259**	**.398**	**.159**	**8.0**	**2.512**	**6.310**	**.178**	**.0316**	**15.0**	**5.623**	**31.62**
.881	.776	1.1	1.135	1.288	.394	.155	8.1	2.541	6.457	.176	.0309	15.1	5.689	32.36
.871	.759	1.2	1.148	1.318	.389	.151	8.2	2.570	6.607	.174	.0302	15.2	5.754	33.11
.861	.741	1.3	1.161	1.349	.385	.148	8.3	2.600	6.761	.172	.0295	15.3	5.821	33.88
.851	.724	1.4	1.175	1.380	.380	.145	8.4	2.630	6.918	.170	.0288	15.4	5.888	34.67
.841	.708	1.5	1.189	1.413	.376	.141	8.5	2.661	7.079	.168	.0282	15.5	5.957	35.48
.832	.692	1.6	1.202	1.445	.372	.138	8.6	2.692	7.244	.166	.0275	15.6	6.026	36.31
.822	.676	1.7	1.216	1.479	.367	.135	8.7	2.723	7.413	.164	.0269	15.7	6.095	37.15
.813	.661	1.8	1.230	1.514	.363	.132	8.8	2.754	7.586	.162	.0263	15.8	6.166	38.02
.804	.646	1.9	1.245	1.549	.359	.129	8.9	2.786	7.762	.160	.0257	15.9	6.237	38.90
.794	**.631**	**2.0**	**1.259**	**1.585**	**.355**	**.126**	**9.0**	**2.818**	**7.943**	**.159**	**.0251**	**16.0**	**6.310**	**39.81**
.785	.617	2.1	1.274	1.622	.351	.123	9.1	2.851	8.128	.157	.0246	16.1	6.383	40.74
.776	.603	2.2	1.288	1.660	.347	.120	9.2	2.884	8.318	.155	.0240	16.2	6.457	41.69
.767	.589	2.3	1.303	1.698	.343	.118	9.3	2.917	8.511	.153	.0234	16.3	6.531	42.66
.759	.575	2.4	1.318	1.738	.339	.115	9.4	2.951	8.710	.151	.0229	16.4	6.607	43.65
.750	.562	2.5	1.334	1.778	.335	.112	9.5	2.985	8.913	.150	.0224	16.5	6.683	44.67
.741	.550	2.6	1.349	1.820	.331	.110	9.6	3.020	9.120	.148	.0219	16.6	6.761	45.71
.733	.537	2.7	1.365	1.862	.327	.107	9.7	3.055	9.333	.146	.0214	16.7	6.839	46.77
.724	.525	2.8	1.380	1.905	.324	.105	9.8	3.090	9.550	.145	.0209	16.8	6.918	47.86
.716	.513	2.9	1.396	1.950	.320	.102	9.9	3.126	9.772	.143	.0204	16.9	6.998	48.98
.708	**.501**	**3.0**	**1.413**	**1.995**	**.316**	**.100**	**10.0**	**3.162**	**10.000**	**.141**	**.0200**	**17.0**	**7.079**	**50.12**
.700	.490	3.1	1.429	2.042	.313	.0977	10.1	3.199	10.23	.140	.0195	17.1	7.161	51.29
.692	.479	3.2	1.445	2.089	.309	.0955	10.2	3.236	10.47	.138	.0191	17.2	7.244	52.48
.684	.468	3.3	1.462	2.138	.306	.0933	10.3	3.273	10.72	.137	.0186	17.3	7.328	53.70
.676	.457	3.4	1.479	2.188	.302	.0912	10.4	3.311	10.96	.135	.0182	17.4	7.413	54.95
.668	.447	3.5	1.496	2.239	.299	.0891	10.5	3.350	11.22	.133	.0178	17.5	7.499	56.23
.661	.437	3.6	1.514	2.291	.295	.0871	10.6	3.388	11.48	.132	.0174	17.6	7.586	57.54
.653	.427	3.7	1.531	2.344	.292	.0851	10.7	3.428	11.75	.130	.0170	17.7	7.674	58.88
.646	.417	3.8	1.549	2.399	.288	.0832	10.8	3.467	12.02	.129	.0166	17.8	7.762	60.26
.638	.407	3.9	1.567	2.455	.285	.0813	10.9	3.508	12.30	.127	.0162	17.9	7.852	61.66
.631	**.398**	**4.0**	**1.585**	**2.512**	**.282**	**.0794**	**11.0**	**3.548**	**12.59**	**.126**	**.0159**	**18.0**	**7.943**	**63.10**
.624	.389	4.1	1.603	2.570	.279	.0776	11.1	3.589	12.88	.125	.0155	18.1	8.035	64.57
.617	.380	4.2	1.622	2.630	.275	.0759	11.2	3.631	13.18	.123	.0151	18.2	8.128	66.07
.610	.372	4.3	1.641	2.692	.272	.0741	11.3	3.673	13.49	.122	.0148	18.3	8.222	67.61
.603	.363	4.4	1.660	2.754	.269	.0724	11.4	3.715	13.80	.120	.0145	18.4	8.318	69.18
.596	.355	4.5	1.679	2.818	.266	.0708	11.5	3.758	14.13	.119	.0141	18.5	8.414	70.79
.589	.347	4.6	1.698	2.884	.263	.0692	11.6	3.802	14.45	.118	.0138	18.6	8.511	72.44
.582	.339	4.7	1.718	2.951	.260	.0676	11.7	3.846	14.79	.116	.0135	18.7	8.610	74.13
.575	.331	4.8	1.738	3.020	.257	.0661	11.8	3.890	15.14	.115	.0132	18.8	8.710	75.86
.569	.324	4.9	1.758	3.090	.254	.0646	11.9	3.936	15.49	.114	.0129	18.9	8.811	77.62
.562	**.316**	**5.0**	**1.778**	**3.162**	**.251**	**.0631**	**12.0**	**3.981**	**15.85**	**.112**	**.0126**	**19.0**	**8.913**	**79.43**
.556	.309	5.1	1.799	3.236	.248	.0617	12.1	4.027	16.22	.111	.0123	19.1	9.016	81.28
.550	.302	5.2	1.820	3.311	.246	.0603	12.2	4.074	16.60	.110	.0120	19.2	9.120	83.18
.543	.295	5.3	1.841	3.388	.243	.0589	12.3	4.121	16.98	.108	.0118	19.3	9.226	85.11
.537	.288	5.4	1.862	3.467	.240	.0575	12.4	4.169	17.38	.107	.0115	19.4	9.333	87.10
.531	.282	5.5	1.884	3.548	.237	.0562	12.5	4.217	17.78	.106	.0112	19.5	9.441	89.13
.525	.275	5.6	1.905	3.631	.234	.0550	12.6	4.266	18.20	.105	.0110	19.6	9.550	91.20
.519	.269	5.7	1.928	3.715	.232	.0537	12.7	4.315	18.62	.104	.0107	19.7	9.661	93.33
.513	.263	5.8	1.950	3.802	.229	.0525	12.8	4.365	19.05	.102	.0105	19.8	9.772	95.50
.507	.257	5.9	1.972	3.890	.227	.0513	12.9	4.416	19.50	.101	.0102	19.9	9.886	97.72
.501	**.251**	**6.0**	**1.995**	**3.981**	**.224**	**.0501**	**13.0**	**4.467**	**19.95**	**.100**	**.0100**	**20.0**	**10.000**	**100.00**
.496	.246	6.1	2.018	4.074	.221	.0490	13.1	4.519	20.42					
.490	.240	6.2	2.042	4.169	.219	.0479	13.2	4.571	20.89	10^{-2}	10^{-3}	30		10^3
.484	.234	6.3	2.065	4.266	.216	.0468	13.3	4.624	21.38		10^{-4}	40	10^2	10^4
.479	.229	6.4	2.089	4.365	.214	.0457	13.4	4.677	21.88					
											10^{-5}	50		10^5
.473	.224	6.5	2.113	4.467	.211	.0447	13.5	4.732	22.39	10^{-3}	10^{-6}	60	10^3	10^6
.468	.219	6.6	2.138	4.571	.209	.0437	13.6	4.786	22.91		10^{-7}	70		10^7
.462	.214	6.7	2.163	4.677	.207	.0427	13.7	4.842	23.44	10^{-4}	10^{-8}	80	10^4	10^8
.457	.209	6.8	2.188	4.786	.204	.0417	13.8	4.898	23.99		10^{-9}	90		10^9
.452	.204	6.9	2.213	4.898	.202	.0407	13.9	4.955	24.55					
										10^{-5}	10^{-10}	100	10^5	10^{10}
											10^{-11}	110		10^{11}
										10^{-6}	10^{-12}	120	10^6	10^{12}

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